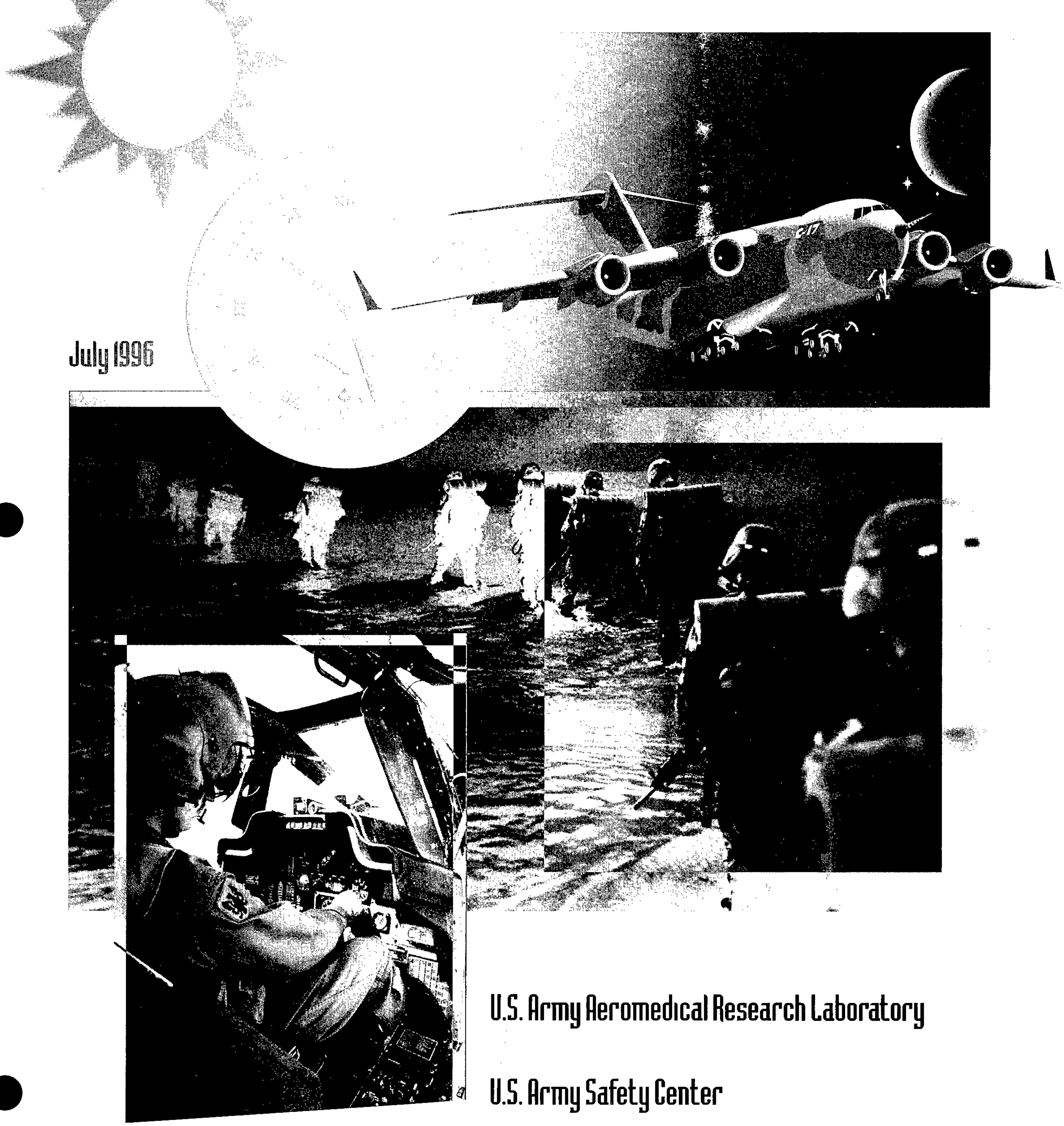
Leader's Guide *to* Crew Endurance

July 1996



U.S. Army Aeromedical Research Laboratory

U.S. Army Safety Center

Acknowledgments

This guide was prepared as a joint effort by the United States Army Aeromedical Research Laboratory (USAARL) and the United States Army Safety Center (USASC).

Authors

Dr. Carlos A. Comperatore, Aeromedical Factors Branch, USAARL
Dr. John A. Caldwell, Aeromedical Factors Branch, USAARL
Dr. J. Lynn Caldwell, formerly with Aeromedical Factors Branch, USAARL

Contributors

LTC John Crowley, former chief Aeromedical Factors Branch, USAARL
LTC Alan D. Davison, formerly with Systems Engineering Division, USASC
MAJ Mark F. Newton, Aviation Branch, USASC
Mr. Dwight Lindsey, Systems Safety Branch, USASC
Ms. Betty Marcum, USASC, editor

Foreword

Stress, fatigue, lack of sleep, and poor adjustment to new schedules are critical issues for military planning during war and peace. Mission failures and accidents frequently result from problems in human performance. Soldiers influenced by these endurance-related issues cannot perform at their best. As a result, these factors may have a direct impact on mission outcome.

Military leaders must have a clear understanding of decreases in performance resulting from human endurance limitations. This guide provides critical information to help you understand the problems, recognize when your soldiers' performance can be expected to decline, and most important, how you can control these problems. More specifically, the guide will provide you much of the information you need to risk manage crew endurance related hazards. Your application of the information provided in this guide will improve soldier performance, effective mission accomplishment, and safety.

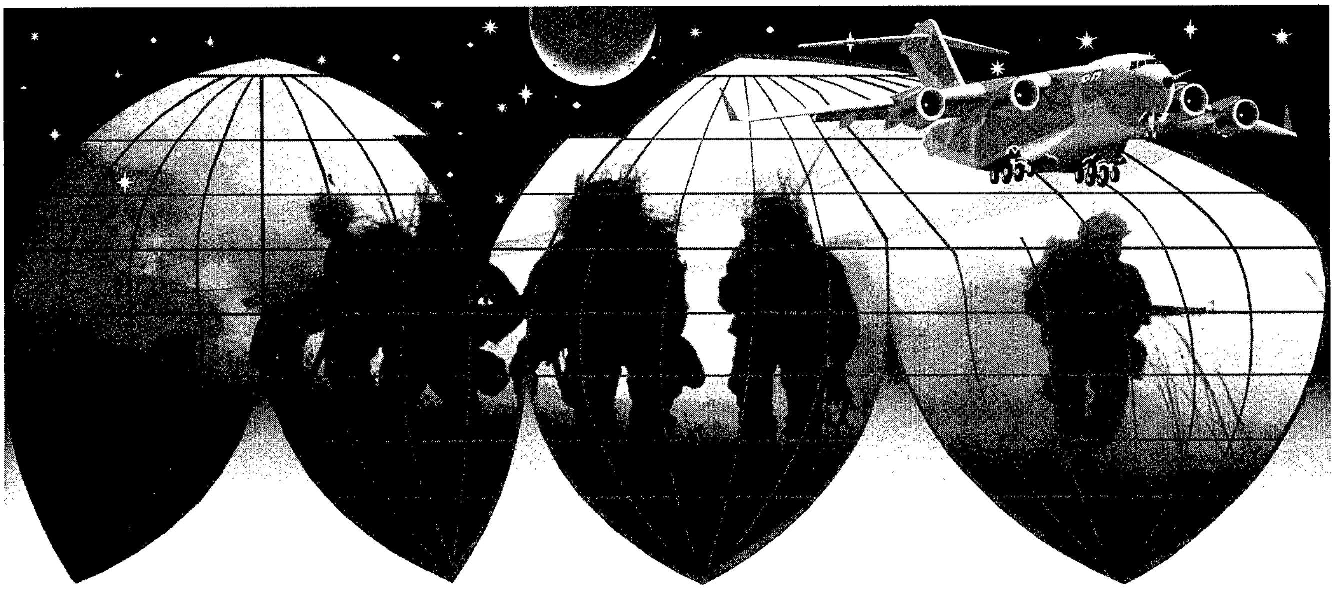
THOMAS J. KONITZER
Brigadier General, USA
Director of Army Safety

DENNIS F. SHANAHAN
Colonel, MC
Commander, USAARL

"It is elementary that there can be no true economy of men's powers on the battlefield unless there is respect for the natural physical limitations of the average individual . . . . The ability to command the loyalties of your men, to learn to think rapidly and resolutely in their behalf while teaching them to do likewise, and to strive always to avoid wasting their force and energy so that it may be applied in strength at the vital time and place—that is leadership of the highest possible caliber."

S.L.A. Marshall
BG USAR-Retired

Table of Contents



Introduction

OBJECTIVE

This leader's guide is about enabling soldiers to perform at their best by controlling stress, fatigue, sleep deprivation, and problems resulting from jet lag and shift lag. It is also about controlling the hazards associated with these stressors when they cannot be completely eliminated. Key users include—

- Mission planners who must design missions in ways that optimize soldier performance.
- Army and unit trainers who must teach leaders about the deleterious effects of these stressors on soldier performance and how to use risk management to prevent and control the hazards they cause.
- Safety managers who must design and maintain the programs.

Crew endurance impacts everything soldiers do. In nearly every case, the stressor reduces the soldier's mental or physical performance. For aviators, this means a larger part of their mental resources must be committed to operating the aircraft, leaving less resources to fight the enemy. For the planner and maintainer, it means less resources available for dealing with the important details of their critical tasks.

Controlling these decrements in performance is critical to mission effectiveness. Today's aviation equipment requires more alertness and concentration of aviators and maintainers than ever before. The demand on mental resources, coupled with the Army's "We own the night" philosophy, increases the potential for crew endurance related problems.

ORGANIZATION

Sections I and II provide guidance to help leaders recognize the detrimental effects of stress, fatigue, and sleep deprivation on soldier performance and the need to control these hazards.

Section III provides guidance on controls that are available to leaders for reducing risk and optimizing performance. Section IV provides tools for commanders and planners to use in developing individual crew endurance plans for their units. The principles in Sections III and IV have been tested by aviation units in developing unit crew endurance plans. These plans have been successfully employed in actual deployments, in operational situations at the National Training Center, and in other field training environments.

HOW TO USE THE GUIDE

Each section of the guide provides—

- A brief background description of the general stressor.
- Signs and symptoms of the general stressor.
- A discussion of resulting hazards and how to manage the hazards based on the five-step risk management process.

Additional information regarding each stressor is provided in appendixes.

LOOKING TO THE FUTURE

This guide is a living document; it will be updated periodically as research and testing by units reveal new information and new methods for using crew endurance to protect warfighters. Already under development by USAARL is a computer software program that will assist planners and commanders in applying the principles in Sections III and IV to developing crew endurance plans for their units.

It is also our hope that information in this guide will be used in training leaders and planners at every level in the importance of crew endurance. When leaders recognize the hazards of fatigue, stress, sleep deprivation, shift and jet lag on the safety and performance of their soldiers, controls will be developed and risks will be managed to protect these soldiers.

This guide is not intended to replace guidelines currently in AR 95-3: *Aviation: General Provisions, Training Standardization, and Resource Management* regarding crew endurance. The fundamental reason for this guide is to provide leaders tools to risk manage crew endurance related hazards. Leaders should use this information along with the guidelines provided in AR 95-3 to minimize risks associated with crew endurance, to ensure crew endurance issues are considered when hazards are assessed, and controls are instituted to ensure mission success.

Section I

Stress and Fatigue

SCENARIO

UH-1V Class C—tree strike

While at 30 feet during a confined area approach, the aircraft's main rotor blades contacted a tree. The crew aborted the approach and landed in an adjacent field.

Result: *Mission loss and damaged aircraft.*

Contributing cause: *Fatigue. For 48 hours prior to the accident, crewmembers had averaged 15-hour plus workdays. They had been on duty for 15 hours just before the accident. All duty was performed in a field environment with less than adequate continuous rest.*

The aircraft was performing a training mission from a field site, transporting passengers under night VFR conditions with unrestricted visibility and 100 percent illumination. Crew rest played a part in the pilot failing to analyze his correct approach angle. It also contributed to failure to solve communications problems within the crew. The lack of crew coordination and unclear terminology between the pilot and medic resulted in the right side of the aircraft not being properly cleared during descent.

BACKGROUND

■ **Fatigue** is the state of feeling tired, weary, or sleepy that results from prolonged mental or physical work, extended periods of anxiety, exposure to harsh environments, or loss of sleep. Boring or monotonous tasks will increase feelings of fatigue. Generally, fatigue interrupts attention and causes slow and inaccurate performance. Short-term or acute fatigue can be reduced or eliminated after brief rest periods. However, chronic fatigue is

more persistent, produces a wider array of effects on performance and morale, and requires longer recovery periods. The focus of this guide is acute fatigue. (See appendix A for further information on fatigue.)

> *Fatigued soldiers perform poorly and behave carelessly, tolerate greater errors, and become inattentive. They display decreased motivation, increased irritability and depression, and/or low morale.*

■ **Stress** is the state of being strained by events to the extent that ability to adapt and respond is difficult or impossible. In some situations, stress responses can be life saving because they provide the extra energy necessary to fight an enemy, succeed at a task, or escape danger. In other situations, stress can be life threatening, especially when chronic or in response to intangible threats. Excessive stress can cause increased fatigue, reduced ability to fight off disease, and increased physical problems.

In military operations, both stress and fatigue result from factors such as long work schedules, demanding tasks, shift work, sleep deprivation, and difficult missions.

> *Army helicopter pilots suffer more fatigue from certain types of flights than from others. The crew endurance guide in AR 95-3 points out that daytime flights under visual flight conditions are the least fatiguing, whereas flights under chemical protective gear are the most fatiguing. Unaided and aided night flights, terrain or nap-of-the-earth flights, and instrument flights fall somewhere between the two extremes. It is important for leaders to recognize that aircrew fatigue will be increased when they fly in the more stressful modes of flight because of the extra effort involved in "staying ahead of the aircraft."*

■ **Indicators of fatigue.** Soldiers who are suffering from fatigue may—

- Have difficulty in attention and concentration. Instructions will have to be repeated because soldiers can't remember what they were told to do.
- Appear dull and sluggish.
- Attempt to conserve energy by reducing body movements to a minimum.
- Sit and stare into space. Even eyeblink frequency will be greatly reduced in soldiers who are extremely fatigued.
- Appear careless, irritable, uncoordinated, and confused.

■ **Indicators of stress.** Chronic stress contributes to an individual's overall level of fatigue, and acute stress can worsen already existing fatigue-related problems. In addition, stress can produce physical complaints such as back pain, tension headaches, gastrointestinal upset, increased blood pressure, irregular heart beats, and difficulty fighting off infections or disease.

HAZARD IDENTIFICATION

■ **Prediction of fatigue.** Leaders can frequently predict the development of fatigue by anticipating the level of stress (both physical and mental) likely to result from planned operations. Assistance in predicting stress can be obtained from such sources as the flight surgeon, chaplain, or safety officer and published guidelines (e.g., AR 95-3 and this guide). Predicting levels of stress and fatigue may allow implementation of controls before the safety risk becomes unacceptable.

■ **Soldier behavior.** Watch for the following changes in behavior in fatigued and stressed soldiers:

- Difficulty concentrating and thinking clearly.
- Poor and careless performance.
- Greater tolerance for error.
- Inattention to minor, but potentially important, details.
- Increased lapses of attention.
- Increased irritability.
- Decreased motivation and conservation of effort

- Increased errors.
- Slow and irregular reaction times.
- Overall reductions in cockpit performance.
- Impairments in communication, cooperation, and crew coordination.
- Complaints of headaches or stomachaches.
- Psychological depression and poor morale.

HAZARD ASSESSMENT

Most of the hazards identified increase the probability of mission failure or accidents. In a few cases, the potential severity of an accident may also be increased. Previously acceptable risks may no longer be acceptable since the frequency of errors is increased by the conditions of stress and fatigue. Leaders may need to reassess the hazard to determine when controls are required.

The hazards associated with stress and fatigue affect aviators, planners, and maintainers. Lapses of attention and failures in crew coordination are precursors for accidents, particularly during highly task-loaded times such as hovering at night. Decreased motivation, difficulty in concentrating, and lack of clear thought processes pose major problems for planners. Poor, careless performance with a greater tolerance for error greatly increases risks associated with maintenance operations.

Review the types of operations your organization will be performing and consider when the hazards resulting from the behavior decrements described are most likely to diminish your soldiers' performance.

CONTROL IDENTIFICATION

Several strategies are available to temporarily reduce the effects of fatigue on job performance. However, there is no substitute for adequate sleep, rest, and time off. For short-term solutions, leaders can—

■ Require a moderate work pace on physically demanding tasks.

■ Provide periodic rest breaks to permit physiological and/or mental recovery.

■ Offer diverting physical activities (e.g., working soldiers alternately between heavy and light duty tasks).

■ Maintain high standards of physical fitness. Emphasize the importance of daily PT. Allowing company time for group PT/games may also improve morale.

■ Ensure soldiers are adequately rested before their work shifts. Enforce a good sleep management plan and crew rest policies (see Section IV and appendix B).

■ Adjust the complexity of duties and make changes in assignments to prevent boredom. If practical, divide up administrative and flying duties into short rotations within each work shift.

■ Provide breaks, naps, or time off after the task has been completed.

■ Provide nutritional food before, after, and/or during work.

■ Ensure soldiers maintain good personal hygiene and health practices. Encourage and provide wellness programs. Monitor with health risk appraisals.

IMPLEMENTATION AND SUPERVISION EXAMPLE

Your aviation unit is required to deploy to a remote location in the tropics and immediately establish defensive positions around a perimeter. Sustained operations will begin with an alert in the early morning hours and will not end until about 48 hours later, when defensive positions are expected to be completed. At this time, flight crews must be ready to perform screening operations. This will require significant physical effort for those "digging in" fighting positions on the perimeter and a great deal of planning for key members of the battalion staff. It is certain that flight crews will have to physically assist in establishing the fighting positions.

The aviation safety officer and flight surgeon have advised the commander to use the following controls to minimize the effects of stress and fatigue:

■ All personnel will be briefed on the effects of fatigue and the importance of good rest and physical conditioning prior to deployment.

■ Since the task will require prolonged physical effort, soldiers will be instructed to work at a moderate pace while "digging in" the fighting positions.

■ Whenever possible, leaders will inform soldiers of the break schedule in advance and will enforce periodic rest periods as required.

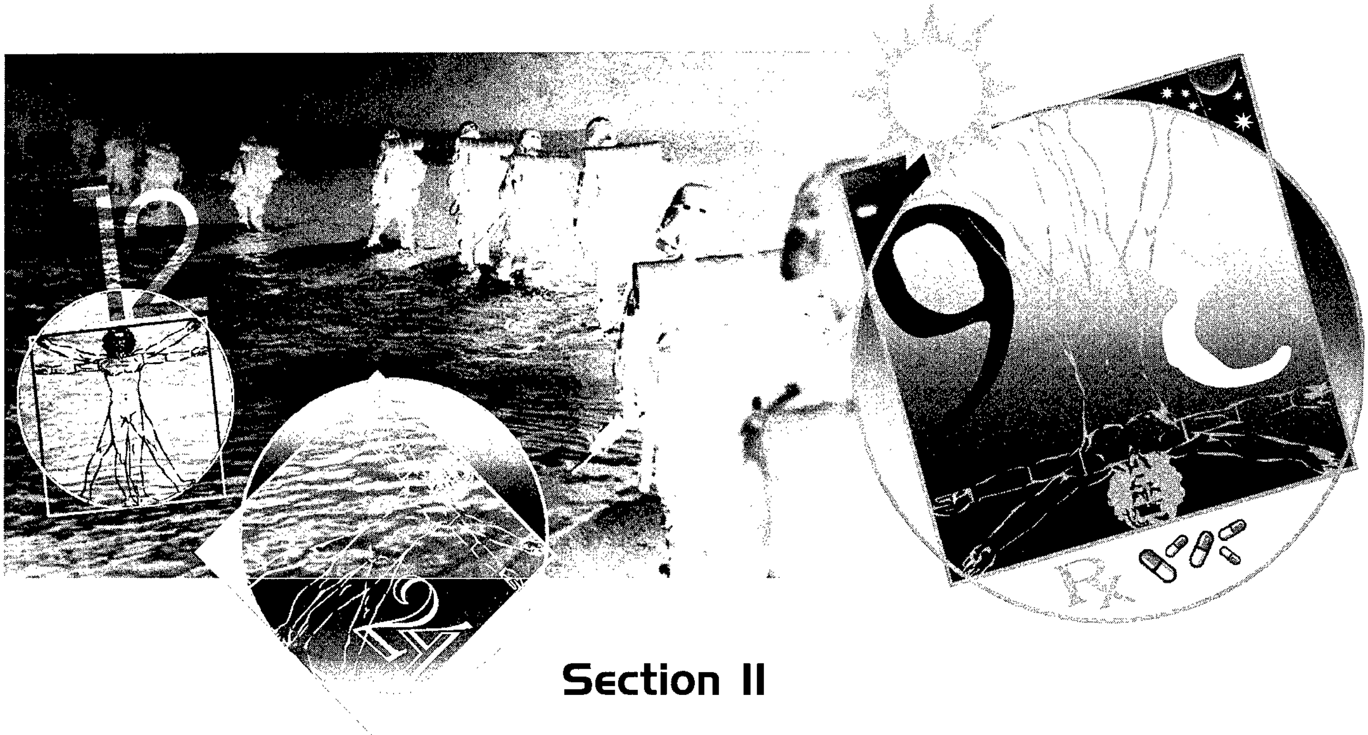
■ When practical, soldiers performing monotonous tasks will be rotated to other jobs at regular intervals to prevent fatigue-related errors.

■ Leaders will be provided environmental data at regular intervals (e.g., Wet Bulb Globe Temperature-WBGT) and will have been well-trained regarding the implementation of Army-published work/rest guidelines for a hot environment.

■ Although flight crews will be required to perform heavy physical labor upon arrival, operations personnel will ensure that they are given sufficient time to rest prior to actual flying on Day 3.

■ Leaders, safety officers, and flight surgeons will be tasked with one-on-one surveillance of flight and maintenance crews, to monitor fatigue levels as the mission progresses. Individuals showing signs of significant fatigue will be given time to rest if possible. Those not able to rest could be teamed with well-rested personnel or assigned to less critical missions. Alternatively, pharmacological aids (discussed in Section II) might be considered if the operational scenario warrants.

For more information contact Dr. John A. Caldwell at the United States Army Aeromedical Research Laboratory, Aeromedical Factors Branch, DSN 558-6864 (334-255-6864).



Section II

Sleep Deprivation

SCENARIO

C-12F Class A—fuel exhaustion

The instructor pilot (IP) was attempting a forced landing due to fuel exhaustion. While turning on final letdown, the aircraft's right engine failed, followed shortly by the left engine. After touching down in a level three-point attitude on a short concrete apron, the aircraft bounced and continued across a ditch, coming to rest in a jungle area in a nose-down attitude.

Result: *Mission loss and major damage to the aircraft.*

Contributing cause: *Fatigue. The IP's duty day started at about 0700 hours, and the accident occurred at 2240. During his 15.5-hour duty day, he had flown 9.5 hours, approximately 4 hours at night compounded by IMC conditions and occasional thunderstorms.*

The IP had previously executed a missed approach at another airfield, and without identifying the airfield and verifying his position, he made a decision to continue flight to another destination. He was overly confident in the navigation equipment he was using, and he did not acknowledge that he was having orientation difficulties or ask for assistance. As a result, the aircraft became critically short of fuel.

BACKGROUND

■ **Sleep** is a physiological need like hunger and thirst. An individual can continue to work for only a limited time before the need for sleep overrides all else. The person then must sleep in order to continue functioning—sleep is the remedy for acute fatigue. One of the major causes of "combat fatigue" is total or partial sleep deprivation. There are both behavioral and pharmacological strategies that should be considered to ensure soldiers receive adequate sleep. These strategies are described in detail in appendixes B and C.

The average sleep length in humans is 7 to 9 hours per day. For most soldiers, the normal sleep length can be

reduced by 1 to 2 hours for an extended period of time without significantly affecting performance, but once the sleep restriction period ends, soldiers will have to revert back to their normal sleep length. Five hours of sleep per night should be considered the absolute minimum for longer-term operations (i.e., 14 days). Greater sleep restrictions will result in adverse effects on behavior, physiology, and performance. Sudden or significant sleep deprivation should be expected to degrade mental skills, mood, and motivation. No amount of training or conditioning will prevent this deterioration.

Some soldiers may tolerate as few as 4 hours of sleep per night for short periods (up to 1 week) without major deterioration in performance, but there is no easy way to determine which soldiers will be able to function well with the least amount of sleep. The decision about how much sleep restriction is feasible should take into account the complexity of the job, the potential for loss that could result from an error (probability and severity), and the individual soldier's tolerance to sleep loss.

Individuals cannot accurately gauge their own level of impairment due to sleep loss. Don't rely on soldiers to tell you when they have lost too much sleep.

■ **Signs and symptoms of sleep deprivation.** Sleep-deprived soldiers will display most of the fatigue symptoms described in Section I (since sleep loss is one of the most common causes of fatigue). However, prolonged chronic sleep deprivation can produce more severe confusion, greater performance decrements, frequent mental lapses, and even delusions and hallucinations.

HAZARD IDENTIFICATION

■ **Prediction of sleep deprivation.** Whenever possible, leaders should anticipate the operational need for sleep. Advance warning may allow the implementation of coping strategies (such as naps) that can prevent or reduce the effects of sleep loss.

■ **Indicators of sleep deprivation.** Soldiers who are suffering from sleep deprivation display some or all of the following symptoms. The more sleep loss there has been, the more pronounced these symptoms will become.

- Increased fatigue (and all of the associated symptoms described in Section I).
- Difficulty concentrating.
- Some decrements in the performance of physical tasks.
- Increased irritability and unreasonableness.
- Psychological and performance deteriorations.
- Decreases in mental abilities.
- Reduced motivation to complete the mission.
- Impaired speed and accuracy of skilled tasks such as handling emergency procedures or responding quickly to enemy threats.
- Occasional visual and tactile (sense of touch) hallucinations.
- Confusion and disorientation.

HAZARD ASSESSMENT

Sleep deprivation causes fatigue-related performance decrements that increase the probability of mission failure or accidents. Previously acceptable risks may no longer be acceptable since the frequency of errors is increased, and the potential severity of an accident may also be increased. Leaders may need to reassess the hazard to determine when controls are required.

Assessing the magnitude of the hazard requires a knowledge of the operational requirements—the workload, the expected duration of the sleep deprivation period, the commander's ability to insert controls, and so forth. It is critically important for experienced observers (e.g., safety officer, flight surgeon, standardization instructor pilot) to monitor soldiers face-to-face to assess the effect of acute fatigue on operational safety.

Guidelines that may be useful in estimating the magnitude of the hazard include:

■ Performance after sleep deprivation tends to improve somewhat during daytime hours and decline at

nighttime (but daytime performance when sleep deprived is still frequently subnormal).

■ Performance on well-practiced, self-paced tasks (e.g., maintenance personnel inspecting aircraft prior to flight) is generally less susceptible to deterioration than performance on demanding, long, or externally-paced work (e.g., air traffic controllers responding to aircraft entering their sectors).

■ Older soldiers (45 years and older) tend to suffer more from sleep loss than younger soldiers on externally-paced tasks, but younger soldiers may suffer more on self-paced tasks because they tend to exert too much effort at the beginning and fail to conserve energy for later.

CONTROL IDENTIFICATION

■ **Preventing the effects of sleep deprivation.** The best way to prevent fatigue associated with sleep deprivation is to ensure that soldiers are well-rested. Given sufficient notice of an upcoming sleep deprivation period, this can be accomplished by scheduled napping (appendix D) possibly assisted by a short-acting sleep aid (appendix C).

Even if operational conditions do not provide advance warning, a good pre-existing sleep management plan (appendix B) can help prevent the performance decrement—soldiers who are chronically well-rested are better able to endure sleep deprivation.

■ **Treating the sleep-deprived soldier.** There are several ways to temporarily minimize the effects of sleep loss once it has occurred:

- Frequently rotate crewmembers on tasks that require a high degree of vigilance to avoid boredom (rotate pilot and copilot duties in a two-person aircraft). Or rotate staff duties with flying duties.
- Closely supervise soldiers and provide immediate feedback regarding the quality of work being performed to increase motivation.
- Postpone difficult or complex tasks such as intricate mission planning, or give these tasks to the least sleep-deprived soldier when possible.
- Allow soldiers to pace themselves so they can maintain accuracy by slowing speed.
- Avoid giving sleep-deprived soldiers tasks that have heavy requirements for short-term memory such as flying, maintenance, staff planning (or give these tasks to the least sleep-deprived soldiers).
- If possible, suspend work requirements during the early morning hours when soldiers are more susceptible to fatigue and efficiency is lower.
- Provide a brief period of exercise immediately before task performance, especially administrative work.
- Use fans in indoor work environments or vents in aircraft to keep soldiers cool, and allow soldiers to splash their faces with cold water to temporarily enhance alertness.
- If possible, delegate more responsibility for work that must be done quickly to younger rather than older soldiers since the effects of sleep loss typically are greater among older soldiers.
- Use napping when appropriate (see appendix D for details).
- In "fly or die" situations, consider the use of stimulants when napping or "adequate rest" is not possible (appendix E).

IMPLEMENTATION AND SUPERVISION EXAMPLE

■ **General example.** Aviation maintenance personnel are required to work 40 hours straight without sleep in order to support a sustained-operations mission. To control the effects of fatigue and sleep deprivation, the unit supervisor should—

- Identify cross-trained personnel and rotate tasks in 2-hour blocks.
- Intersperse especially boring tasks with short (5-minute) breaks every 30 minutes to allow soldiers to move around.
- Ensure that information and instructions are provided in written form.
- Provide soldiers frequent and constant feedback regarding the quality of their work, but be sure they are not pressured to work too fast or mistakes will be more likely.
- Provide nutritious foods and fluids.
- Encourage physical activity.

- Inform soldiers when they will be finished with the work shift so they can look forward to their time off. Be sure they get the expected time off.

If the pace of operations or the available staffing level permits, naps can be used to sustain performance during the continuous work period.

■ **Napping, example 1.** A commander knows a continuous operation (CONOPS) is being assigned beginning at 2400. The commander may elect to—

- Ensure all soldiers are permitted to take a 4-hour nap sometime between 1200 and 2400 prior to the CONOPS period (preferably from 1900 to 2300).
- Allow one group of soldiers to take a 2-hour nap after 24 hours of work. Keep in mind that soldiers who nap from 0100 to 0300 will have significant sleep inertia and should be allowed 30 to 45 minutes to recover before returning to duty. After the 2-hour nap and recovery period, this group of soldiers will be able to work for another 12 to 15 hours.
- Allow another group of soldiers a 2-hour nap from 0600 to 0800. Upon awakening, the sleep inertia for this group will be less than for the group who napped at the earlier time, but the second group of soldiers should still be allowed 15 to 30 minutes of recovery time (appendix D).

■ **Napping, example 2.** A CONOPS occurs without warning and without adequate time for any napping prior to start. Soldiers can operate for 24 to 32 hours (depending on the type of job) before a nap is strongly recommended (although performance loss will occur between 0200 and 0600). Note that some individuals, especially those performing monotonous tasks (including long flights), may suffer severe performance decrements after the loss of a single night's sleep.

To avoid significant sleep inertia after napping and to minimize the duration of sleep loss, the commander decides to—

- Encourage soldiers to nap as soon as the mission allows. Sleep will be easiest to obtain in the early morning hours, but sleep inertia will be greatest after napping at this time.
- Allow a 10- to 20-minute nap every 2 to 4 hours if soldiers cannot be permitted to nap for a longer period. These short naps will allow continuous performance for long periods of time. After these short naps, however, sleep inertia will occur and will be most pronounced during the early morning hours (0100 to 0500).

It may be difficult for soldiers to wake up from a short nap during the early morning, particularly if they have been deprived of sleep for 36 hours or more (appendix D).

■ **Napping with medication, example 1.** Soldiers are in a field environment, working around the clock with little time for sleep. Some soldiers have 3 to 5 hours of free time for napping, but the free time occurs during a time when sleep does not come easily. A short-acting sleep aid could be administered, and the soldier then could sleep for 2 to 4 hours, awakening 1 hour before time to report to work (appendix C).*

■ **Napping with medication, example 2.** A CONOPS mission is scheduled to begin at 2400 hours, but environmental conditions are highly unfavorable for restful sleep. A short-acting sleep aid could be administered at 1900, the soldier then could sleep until 2300 and report for duty at 2400 for a 24-hour continuous work period (appendix C).*

Stimulants have been used by the military since World War II. The decision to use stimulants requires close coordination by the unit commander, planners, safety officer, and flight surgeon.

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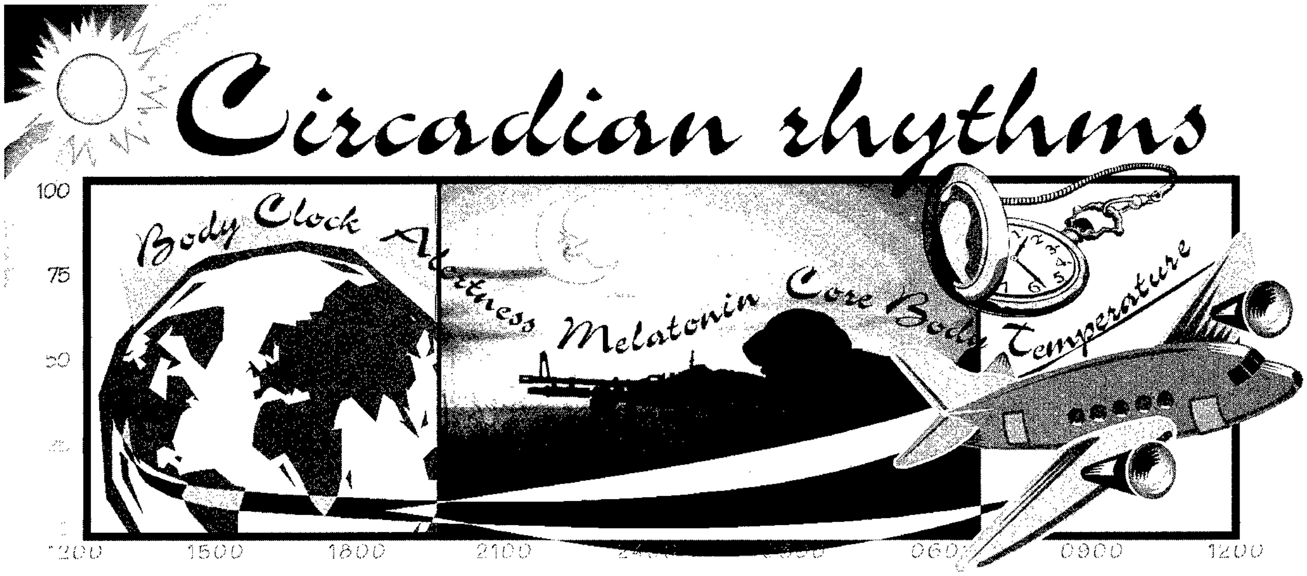
*Aviators are restricted from flying duties for a specified time following administration of sleep aids. For detailed guidance regarding use of sleep aids, see appendix C, table 2.

■ **Stimulants, example 1.** Soldiers are in a life or death combat situation, working around the clock with no time for sleep. The radar monitoring task and staff work are boring, and soldiers are falling asleep at their positions even after trying nonpharmacological techniques to maintain alertness. After obtaining proper approvals from the chain of command, dextroamphetamine could be administered by the flight surgeon to critically fatigued individuals to preserve vigilance (appendix E).

■ **Stimulants, example 2.** An aviation unit is given advance notice of a "must fly" combat mission requiring a 40-hour sleep deprivation period (0600 on Day 1 to 2200 on Day 2) with almost continuous flight operations. Anticipating dangerous levels of acute fatigue, permission is obtained from the chain of command to issue each aviator a small number of dextroamphetamine 5-mg tablets for the mission. The flight surgeon provides instruction to the aviators regarding "go pill" usage, and each individual has been pretested to preclude unusual side effects. The flight surgeon personally issues each aviator's supply immediately before the mission and collects all unused medication after the mission to maintain controlled-substance accountability (appendix E).

Research by Dr. J. Lynn Caldwell. For more information contact the United States Army Aeromedical Research Laboratory, Aeromedical Factors Branch, DSN 558-6862 (334-255-6862).



Section III

Work Schedules and the Body Clock

SCENARIO

OH-6J Class C accident—landing with tail wind

The aircraft was on approach to an unimproved area in high-desert mountainous terrain. On short final, the pilot realized he was landing with a tail wind and made an unsuccessful attempt to make a go-around. Realizing he had no power available, he elected to land. The aircraft hit a large rock, breaking the skids off. After spinning around, the aircraft came to rest on its right weapons mount.

***Result:** Mission loss and a damaged aircraft.*

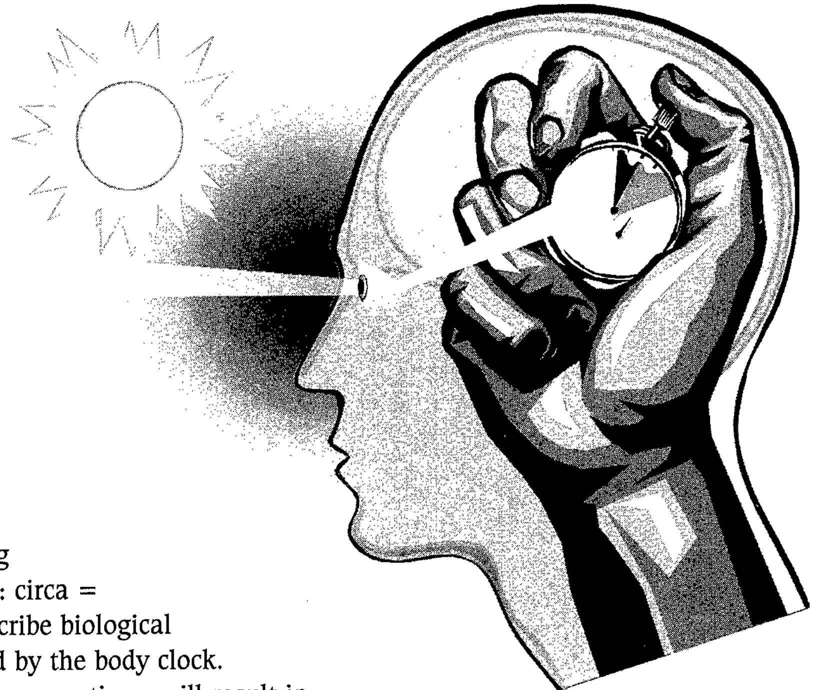
***Contributing cause:** The crewmembers were experiencing a combination of jet lag and shift lag, resulting in circadian desynchronosis.*

The crew had been ordered to perform a stand-to for 30 minutes past dawn at a field site after performing a night flight that ended just before dawn. Exposure to the sun's rays probably altered their internal biological clock. In addition, their sleep for several days prior to the accident never occurred during the "anchor time zone" between 2300 and 0700.

BACKGROUND

■ **The human biological clock.** The biological clock regulates the daily availability of physical energy and mental resources. The daily environmental rhythm of daylight and darkness is the time-giving cue that regulates the biological clock. As daylight energizes the retina in the back of the eye, a neural message is conveyed to brain centers and glands that make up the human biological timing system.

- The availability of mental and physical resources fluctuates during the 24-hour day. The best and worst times of day are determined mostly by light cues received by the body clock.



- Seeing daylight after a normal night's sleep sets the body clock in a day-oriented pattern. This means that physical and mental energy peaks daily during daylight hours between 0800 and 1200, decays slightly between 1300 and 1500, then increases between 1500 and 2100, and finally declines from 2200 through 0600.
- The body clock controls specific patterns of hormones, alertness, and core body temperature among others. The word circadian (Latin: circa = about; dies = day) is used to describe biological and behavioral rhythms regulated by the body clock.
- Lack of consistency in daylight exposure times will result in unpredictable availability of alertness, cognitive, and physical resources.
- If wake-up times and daylight exposure vary continuously from day to day (e.g., plus or minus 5 hours), the body clock receives inputs that are similar to very frequent travel across time zones. Such unstable sleep/wake schedules, caused by either changes in work schedules or travel across time zones, may disrupt body-clock timing and ultimately induce **circadian desynchronosis** or **maladaptation**.
- Circadian desynchronosis or maladaptation is the syndrome underlying the symptoms of jet lag and shift lag. Classic symptoms include fatigue, malaise, sleepiness, lack of motivation, confusion, and digestive disorders.
- After rotating into nighttime shiftwork or after traveling across time zones, the symptoms of fatigue, sleepiness, and lack of motivation are indications that circadian desynchronosis has set in. These body clock disruptions increase the mission risk level and can compromise safety (appendix F).

■ **Shift lag.** As soldiers transition from one work schedule to another, physical and mental resources lag behind the rapid change in the sleep/wake cycle. The most difficult challenge to the body clock occurs during the transition from the day shift into the early morning shift or into nighttime duty hours. This condition is called shift lag because the timing of the body clock always lags behind the sudden change in work/rest schedule.

Example. An air traffic controller who works the morning shift from 0600 to 1400 and then rotates to the night shift from 2300 on the same day to 0700 the following morning has particular difficulty staying awake because of the combined effects of sleep loss (after waking up early that morning at 0400) and the effects of shift lag (after rotating into the night shift on the same day).

■ **Jet lag.** After travel across time zones, physical and mental resources lag behind the rapid change to the destination light/dark cycle and the new sleep and work schedule. Following eastward or westward travel during which four or more time zones are crossed, readaptation can take from 4 days to several weeks. The amount of time required for readaptation depends on whether effective coping strategies (discussed later in this section) are implemented soon after arrival to the new time zone. Inconsistent sleep/wake and daylight-exposure schedules will delay adaptation of the body clock to the destination time zone.

Example. A soldier deploying eight time zones to the east is required to work immediately upon arrival. Her job requires her to work inside a tactical operations center (TOC) van during the day. This soldier may not easily get the light exposure that would speed adaptation to the new time zone. If good coping strategies are not instituted, critical performance errors may occur because she is working through her body clock's nighttime period (the period of worst performance) and her adaptation to the destination time zone will be delayed.

■ **Causes of desynchronosis.** Although the symptoms associated with shift and jet lag are very similar, their mechanisms differ. In jet lag, desynchronosis is induced by the change in sunrise and sunset times caused by crossing several time zones. In shift lag, desynchronosis is caused by the change in work and sleep schedules and the corresponding change in daylight exposure time.

■ **Signs and symptoms of circadian desynchronosis**

- Fatigue and sleepiness during the work period.
- Sleep disruptions.
- Poor concentration.
- Impaired decision-making ability.
- Digestive disorders.

HAZARD IDENTIFICATION

■ **Prediction of desynchronosis.** It is usually easy to predict shift lag or jet lag. Anytime the work schedule and sleep/wake cycle are shifted suddenly, soldiers will be at risk for circadian desynchronosis. Given sufficient notice, the measures outlined in this guide can minimize the effects of this body-clock disruption. However, operational conditions may not provide sufficient warning to implement a carefully organized set of coping strategies, and some degree of desynchronosis may be inevitable.

■ **Indicators of desynchronosis.** A variety of signs can be detected in soldiers experiencing circadian desynchronosis. Most are also characteristic of simple fatigue, so it is most important to consider the context and recent body-clock history. The following may be present in soldiers suffering from circadian desynchronosis (with or without simple fatigue):

- Vacant stare.
- Glazed eyes.
- Pale skin.
- Body sways upon standing.
- Walking into objects.
- Degraded personal hygiene.
- Loss of concentration during briefings.
- Slurred speech.

The following two operational scenarios illustrate the difference between jet lag and simple fatigue.

Example 1. Two days ago, your unit arrived in-country, having crossed eight time zones with little advance warning. The flight surgeon tells you, the commander, that many of your soldiers appear generally fatigued, are falling asleep during duty hours and napping frequently, but are having difficulty sleeping through the planned sleep period. Taking into account the recent sudden shift in work/rest cycles, you agree with the flight surgeon that these soldiers are suffering from jet lag.

Example 2. Two days ago, your platoon deployed thousands of miles southward (no time zones were crossed). After a 10-hour aircraft flight, soldiers were required to set up camp all night, resulting in sleep deprivation. Because of the optempo, little structured sleep has been possible, and some soldiers are falling asleep during duty hours and napping frequently. Those few who are allowed to sleep have no difficulty in sleeping soundly for many hours. Because no time zones were crossed and the troops do not appear to have

difficulty obtaining rest (when given an opportunity), you conclude that your soldiers are suffering from acute fatigue, not circadian desynchronosis.

HAZARD ASSESSMENT

Gauging the severity of circadian desynchronosis depends largely on the operational scenario. That is, a sudden change of eight time zones is obviously of more concern than a long-planned trip across three time zones. There are, however, factors that can assist leaders in assessing the magnitude of a desynchronosis problem.

■ **Predicting desynchronosis severity.** When planning a shift in work schedules, consider the following factors:

- Rotations from daytime duty hours to nighttime or early morning duty hours will always result in some degree of sleep loss and fatigue during the initial day of transition. Controls should be implemented from the beginning of the work-schedule change.
- Night shifts ending around sunrise will pose the greatest challenge to the body clock and are associated with more severe desynchronosis.
- Rotations from daytime duty hours to afternoon or evening work schedules do not require rapid adjustment of the body clock. These rotations can be considered benign compared to rotations into night or early morning duty hours.
- Return to daytime duty hours after several days or weeks of nighttime or early morning duty hours produces significant desynchronosis and should not be underestimated. At least 3 days are required to rotate from nighttime to daytime duty hours.
- Eastward or westward travel across more than one time zone will result in some degree of jet lag. This may manifest as fatigue in the early night for westward travellers and reductions in total sleep duration for eastward travellers. Increasing the number of time zones crossed results in greater severity of symptoms. Although westward travel is usually considered more benign than eastward travel, controls are required in either case.

■ **Individual differences.** Some soldiers are more susceptible to jet lag/shift lag than others. When selecting soldiers for a particular mission or shift, it may be useful to consider these tendencies. Remember that these are not absolute—the best guide may be previous experience with the soldier in similar operational situations.

- Individuals who prefer early-morning rise times (e.g., from 0400 to 0600) and early bedtimes (e.g., from 2000 to 2100) tend to easily adjust to early morning duty hours. In contrast, individuals who prefer to retire at 2200 or later and rise after 0700 tend to adjust more easily to nighttime duty hours than early-morning duty hours. These preferences are often masked by work schedules, so they are not easy to detect. In the process of selecting personnel, it may be useful to determine their preferred bedtimes and rise times during off-duty days.
- It is more difficult to identify individual sleep preferences that predict the ability of soldiers to cope with jet lag. In this case, it is better to implement controls than to attempt to select the more apt soldier.
- Soldiers who are more than 40 years of age may experience sleep disturbances and gastrointestinal disorders more frequently than younger soldiers. Controls are required for both populations, although young soldiers tend to experience benefits more quickly than the over-40 population.

■ **Assessing the current hazard.** Once circadian desynchronosis has developed, it is difficult to treat. To estimate the magnitude of a body-clock problem, consider the soldier's body-clock history, the severity of the signs and symptoms previously listed, and the following factors that may affect safety:

- **Impaired self-observation.** Desynchronosis is usually accompanied by severe sleep loss, with an attendant fatigue-related inability to adequately judge one's own behavior.

  When unit members experience jet lag or shift lag, their inability to adequately assess self-performance may jeopardize safety. Crewmembers may not be able to reliably determine if they are safe to fly and may not respond to subtle warning remarks made by peers.

- **Impaired communication.** Soldiers suffering from desynchronosis may have difficulty communicating critical mission, flight, or safety information.
  - ◆ Conversation may become fragmented and contain repetitive phrases and ideas.
  - ◆ Weariness makes verbal communication very difficult and tends to result in misinterpretation.
  - ◆ Failed verbal communication can cause orders and warnings to be ignored.
- **Increased irritability.** Irritability and impatience are commonly experienced in association with desynchronosis. One positive aspect of increased arguing is that it shows soldiers are still talking to each other, exchanging orders and messages. When bickering ceases, this may indicate mental exhaustion. This is particularly dangerous if a crew is flying back from a night mission between 0400 and 0700. During this period, crewmembers may experience sleepiness and degraded alertness and cognitive function will be at its lowest. The combination of acute fatigue with desynchronosis can be lethal.
- **Physical exertion.** The perception of exertion changes as a function of time of day. Desynchronosis can interfere with soldiers' ability to judge the physical difficulty of a task.

When possible, avoid flying between 0400 and 0700 after working all night. Fatigue can be overcome more easily between 2400 and 0300.

CONTROL IDENTIFICATION

The timing of sleep is critical in the management and prevention of desynchronosis. Maintaining consistent schedules that ensure well-timed sleep can be difficult in the operational setting, but it is essential. Once shift lag or jet lag actually develops, returning to normal can take several weeks of a consistent sleep/wake schedule. Desynchronosis symptoms are unlikely to disappear in just a few days of normal sleep. Appendix F contains detailed recommendations for controlling circadian desynchronosis using the following categories of countermeasures:

■ **Napping.**[1] In the context of body-clock adjustment, naps are recommended if—
- Soldiers rotate from day to night shift, and
- Soldiers cannot sleep more than 4 to 5 hours during the sleep period, and
- The next night is going to be another work period.

Detailed scheduling advice is contained in appendix F.

■ **Pre-adaptation.** Before deployment, a unit can attempt to pre-adapt to the new work shift or destination time zone. While potentially useful, pre-adaptation requires much coordination and cooperation from all levels of the involved unit. In a pre-adaptation scenario, deploying elements typically begin shifting their sleep/wake cycle from origination time toward the new sleep/wake cycle several days before transition. Operational considerations are in appendix F.

■ **Timed light exposure.** The timing of daylight exposure is critical for the resynchronization of the body's biological clock. By carefully scheduling exposure to sunlight or proper artificial light, it is possible to speed adaptation to a new work schedule and/or time zone. Note, however, that incorrect timing of light exposure can actually worsen jet lag, so planners should carefully follow the specific suggestions provided in the scenarios later in this section and in appendix F.

The advantage of a plan to prevent desynchronosis far outweighs any possible gains derived from not taking the time to carry it out.

[1] For a general discussion of napping, see Section II.

CONTROLS FOR NIGHT OPERATIONS/SHIFT LAG HAZARDS

The following general recommendations for night operations take into account the role of daylight, the timing of sleep, and the use of darkness during resynchronization to a new work schedule. In many military work environments, such as maintenance shops or tactical operation centers, the quality of daytime sleep may be protected by observing the following countermeasures:

- Use sufficiently bright lights in the work environment during the night shift in order to resynchronize the circadian timing system to the nocturnal schedule. (This strategy must be weighed against tactical concerns as indicated below.)
- Maintain near to complete darkness in daytime sleeping quarters.
- Reduce daytime environmental noise to a minimum (e.g., traffic noise).
- Follow a consistent sleep- and meal-timing schedule from day to day.
- Eat light meals prior to retiring and schedule the heaviest meals around 1300 to 2000.
- Maintain the same schedule of sleep, wake-up, and meal times during days off.
- Avoid frequent shift rotations. Allow shifts to continue for at least 2 to 3 weeks.

UNIQUE PROBLEMS OF THE NIGHTTIME ARMY AVIATOR

Exposure to bright light during or prior to nighttime flying operations is not recommended because it may interfere with the process of dark adaptation. The use of bright lights during combat conditions is not tactically feasible. Consequently, Army pilots flying and fighting at night are compelled to experience the effects of shift lag and are not usually able to get the critical light exposure that would help adjust their body clocks to the night duty schedule. The quality and duration of sleep are frequently further degraded by a lack of properly darkened sleeping quarters and a lack of control over environmental noise.

There are, however, several effective countermeasures the nighttime Army aviator can employ. A general night operations crew rest plan for Army pilots might include the following countermeasures:

- Avoid working after 0400 to prevent the harmful effects of fatigue on performance and the pronounced tendency to fall asleep from approximately 0400 to 0700. This countermeasure particularly applies to NVG training periods and to night work schedules ending at approximately 0400 to 0700.

- Avoid exposure to daylight in the morning after flying a night mission in order to minimize the natural synchronization of physiological and cognitive resources with daylight hours. Exposure to sunlight before bedtime can severely retard adaptation to night shift and result in the reduction of total day sleep time and its restorative quality.

- Schedule sleep to begin between 0400 and sunrise time, and delay exposure to sunlight until approximately 1200. Upon awakening, engage in outdoor activities as much as possible in the afternoon. Unavoidable early-morning exposure to sunlight can be reduced by dark sunglasses.

- When possible, sleep in complete darkness and avoid even momentary exposure to sunlight during the sleep period. In order to facilitate proper rest, sleeping quarters should—
  - Isolate night-shift personnel from the activity of day shifters.
  - Reduce environmental noise.
  - Reduce sunlight in all living areas during sleep periods (including restrooms).

- Properly timed naps can be useful in temporarily restoring performance to normal or near-normal levels. Specific guidance for napping is provided in appendixes B and F.

CONTROLS FOR JET-LAG HAZARDS[2]

■ In general, the biological clock (and thus the timing of sleep and wake-up times) will tend to remain oriented to the origination time (OT) zone and adapt slowly to the destination time (DT) zone and mission work schedule. Crossing more than four time zones is particularly difficult and may require a long period of readjustment (4 to 14 days). The following recommendations can serve as general guidelines to help speed adaptation to the new schedule. Specific countermeasures geared to various deployment scenarios are presented in appendix F.

■ **Prior to deployment**, the unit may wish to pre-adapt soldiers to the DT zone, as previously discussed. This may be difficult, or even inadvisable, because of the resources required. However, pre-adaptation is usually beneficial, serving to ease the "shock" of a sudden transition to a new sleep/wake cycle.

Several days (3 to 7) prior to deployment, it may be useful to decrease caffeine consumption to no more than two cups of coffee per day or three carbonated-caffeinated beverages per day. This will then enhance the effects of caffeine during the actual deployment, when the alerting effects are needed. Do not exceed two cups of coffee during the work period.

■ **During travel**, deploying soldiers should be shifting to DT:

- Sleep should occur based on DT and should be avoided at other times.
- In deployments requiring the advance of sleep onset for more than 4 hours, the flight surgeon may wish to dispense sleep aids for use during travel, after considering mandatory grounding times for aviators.

■ **Upon arrival** at the new destination, unit members should maintain regular wake-up times matching the duty schedule. Upon awakening, they should seek daylight exposure as much as possible, particularly during the first 3 days of adaptation. Daylight exposure should be optimized to reset the body clock. The timing of light exposure can be complex and, if improperly administered, can actually worsen desynchronosis. The scenarios provided in appendix F contain tailored recommendations for light exposure.

■ **Specific deployment scenarios.** The nature of the hazard control will depend on the operational situation. For example, eastward and westward deployments require different control measures. Appendix F contains specific recommendations for the following deployment conditions:

- Eastward deployment, daytime duty hours.
- Eastward deployment, nighttime duty hours.
- Westward deployment, daytime duty hours.
- Westward deployment, nighttime duty hours.

IMPLEMENTATION AND SUPERVISION EXAMPLE

A mission is received that will require UH-60 crews to fly nightly troop lifts to forward combat positions for approximately 2 weeks, beginning that evening. Mission durations vary, with some missions ending between 0100 and 0300 and others ending between 0500 and 0600. Crews will be assigned to missions randomly, so it is difficult to assure flying the same hours from night to night. Night operations are expected to last more than 2 consecutive weeks. This tasking will require soldiers to work a full daytime duty day on the first day (approximately 0600 to 1700) and to report for preflight briefings at 2000 later that same night.

Commanders, leaders, and staff have reviewed the situation and identified a set of controls that will minimize the effects of fatigue, sleep loss, and shift change. They have also worked to ensure that controls will be implemented, and supervision is provided to ensure they are effective. The following describes how the controls will be implemented and the supervision that will support the program.

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[2] References to body time, pre-deployment time, or OT zone allude to the timing of the individual's body clock prior to beginning travel.

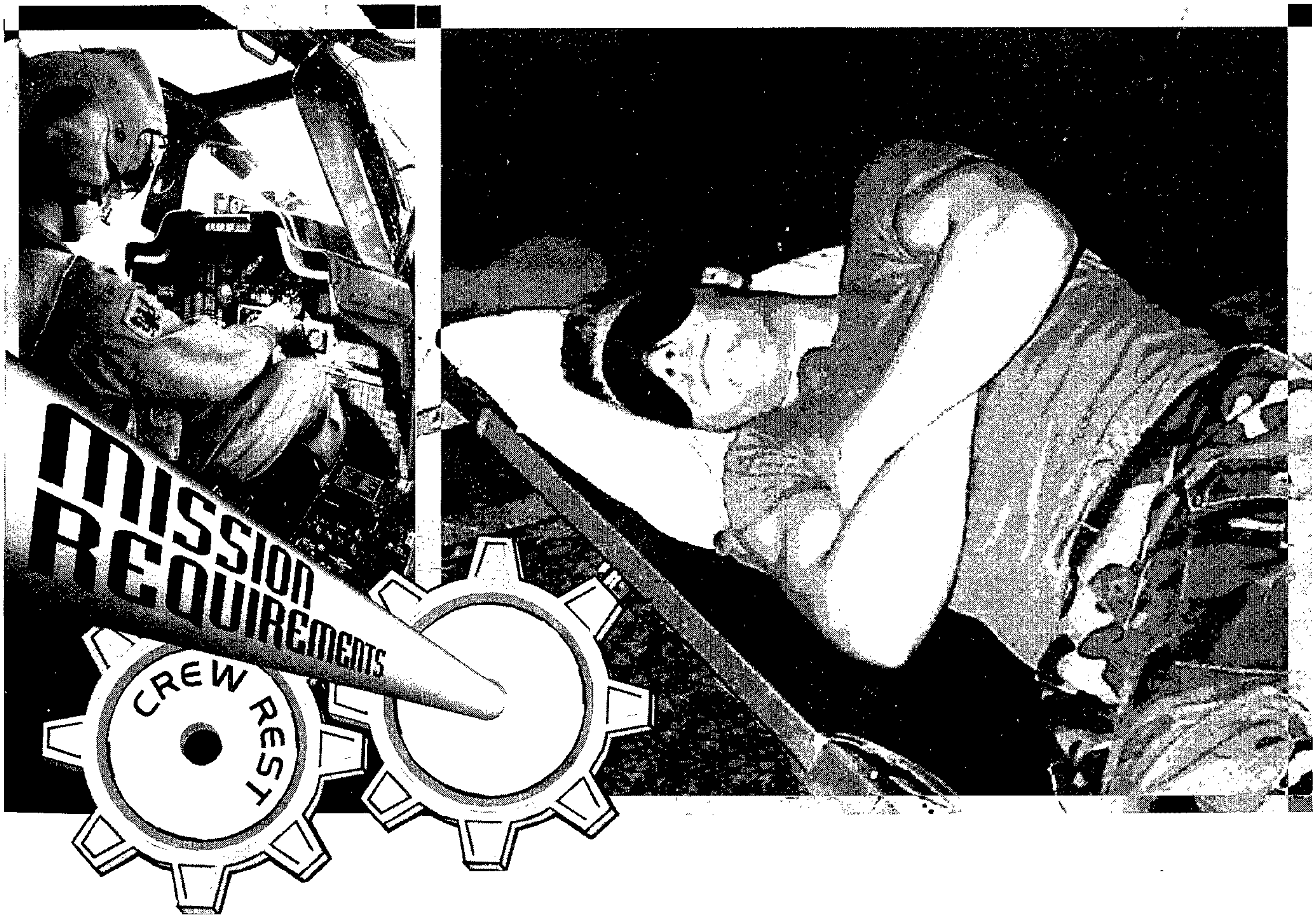
■ **Implementation of controls.** Several controls have been recommended to reduce the effects of shifting to the night schedule, including:

- **Napping.** Soldiers working the night shift will be required to nap between 1800 and 1930 hours during the first 3 days of the transition to night operations. Naps will improve alertness during the night, but crews should avoid, if possible, flying the early morning hours (0300 to 0700) on the first day of the rotation. Leaders will need to be sure that meals are available at times that will not interfere with the napping schedule.
- **Beginning sleep at the proper time.** Sleep should begin as close to 0400 as possible (even if flying is completed prior to this time). Every effort should be made to begin sleep prior to sunrise to avoid exposure to daylight. Daylight exposure should be delayed until approximately 1200 hours. These soldiers will have dark sunglasses available to them to reduce sunlight exposure when it cannot be avoided. This will orient the body clock to a nighttime work cycle.
- **Bright light exposure.** Bright lights will be used in the tactical operations center, maintenance shops, and other areas where soldiers are required to work nighttime hours. Exposure to bright light between 2000 and 0300 could improve adaptation to this schedule. While this would not be recommended for nighttime flight crews or drivers because of night-vision impairment, it may be useful for ground crews or staff personnel.
- **Adjustment of meal schedules.** Soldiers working the night shift will eat breakfast after awakening. This means coordination must be made to serve breakfast during the early afternoon time period.
- **Sleep masks.** Soldiers working the night shift will be required to wear sleep masks during their sleep period to avoid inadvertent exposure to daylight.
- **Coordination of unit activities.** All briefings, maintenance, and training will be scheduled to take place outside the designated sleep period.
- **Protected sleep period.** The sleep period will be protected from impact noise by using power generators to mask such sounds. Commercially available sound masking devices may also help mask environmental noise during the day. Ear plugs also provide an alternative, and combining their use with sound masking may be most effective.

Each of the controls described can be effective only when supervision by leaders ensures they are implemented and enforced.

Work-sleep-nap schedules are available to assist leaders in easing the transition to night operations. Table 4 in appendix F provides detailed work schedules to use during the change to night shift as well as during the return to day operations.

For more information contact Dr. Carlos A. Comperatore at the United States Army Aeromedical Research Laboratory, Aeromedical Factors Branch, DSN 558-6858 (334-255-6858).



Section IV

The Systems Approach to Crew Rest

GENERAL

A comprehensive crew-rest program must involve all personnel, equipment, and policies that impact mission accomplishment and safety. Too frequently, essential elements are left out of coordination and planning until too late, resulting in unacceptably high levels of fatigue and frustration. For example, failing to anticipate the need for separate tents and meals for night and day flight crews is likely to result in the disruption of the night crews' rest period. Employing a "systems approach" to crew rest is a way of ensuring that key players at every level are involved in mission planning and execution, interacting in a coordination network. This integrated approach requires that planners have detailed knowledge of mission requirements and how to organize human resources to accomplish the mission while preserving necessary human-performance levels.

This systems approach to crew rest makes use of a model comprising a set of coordination "elements" that are organized around (and driven by) the mission requirements (figure 1). These elements, which will change according to the specific mission, are arranged in three levels of coordination: individual, unit, and materiel. In general, the levels describe a continuum of flexibility—the mission demands directly determine soldiers' schedules, etc., and are frequently impossible to control. The components of the support level, however, are managed by the unit and relatively easy to control. After a brief description of the levels of the model, individual elements will be discussed in more detail.

LEVELS OF THE MODEL

The center of the model is composed of mission requirements—the stressors over which the unit has no control—that create the need for a crew-rest plan. The mission requirements determine the unit's work/rest cycles, mission flight schedules, optempo, and flight environment (table 1). The elements of a crew-rest model for a particular mission depend on the unique requirements of that mission.

Table 1: Example of Mission Requirements That Compromise Crew Rest

MISSION REQUIREMENT	RESULTING STRESS
LONG-DISTANCE FORCE PROJECTION	JET LAG
NIGHT OPERATIONS	SHIFT LAG
NIGHT VISION GOGGLES	FATIGUE
CONOPS/SUSOPS	SLEEP DEPRIVATION
CHEMICAL THREAT	NBC GEAR/HEAT STRESS

The **individual level** comprises strategies that, although developed by unit planners based on the mission requirements, must be implemented by the individual soldier. Since individual-level elements are driven directly by the mission, they are less amenable to adjustment or modification than are unit- or materiel-level elements. For example, the sleep/rest cycle for aviators in an attack platoon is highly dependent on the mission schedules handed down from higher headquarters. Individual-level elements are critical to the effectiveness of the crew-rest plan and include strategies that help prevent fatigue, sleep deprivation, jet lag, and shift lag. They include:

- A sleep-management plan.
- A daylight-exposure-management plan.
- An environmental-management plan.
- A living-quarters plan

The **unit level** includes coordination of scheduled unit activities that involve groups of soldiers. These elements must be scheduled after considering the individual-level schedules (e.g., meal schedules should be developed after the sleep-management plan is completed). Most unit-level elements can be customized by the unit. Examples are:

- Briefing schedules.
- Meal schedules.
- Training schedules.
- Flight schedules.
- Guard-duty schedules.
- Kitchen-police-duty schedules.

The **materiel level** involves work schedules and activities associated with the equipment used to accomplish mission objectives. In an aviation unit, elements in the materiel level are primarily concerned with maintaining and operating aircraft. This level is the most flexible and can often be tailored to the individual-level schedules. For instance, if a crew is scheduled to sleep between 0400 and 1000, aircraft refueling operations near their tents should be scheduled to occur after their wake-up time. Materiel-level elements include activities such as—

- Aircraft management.
- Aircraft refueling.
- Maintenance schedules.
- Maintenance-request network design.

Figure 1: Crew-rest model

INDIVIDUAL-LEVEL ELEMENTS

■ **Sleep-management plan.** The sleep-management plan should be designed to allow a continuous sleep period lasting up to 8 hours. A knowledge of mission requirements such as deployment timing and tactics must precede the design of the sleep-management plan. Then, bedtimes and wake-up times can be scheduled around the deployment schedule or flight mission. Other schedules such as meals, briefings, and aircraft maintenance (elements of unit and materiel levels) must then be adapted to the sleep-management plan.

After the plan is approved, it should be passed down the chain of command accompanied by training to ensure that every soldier understands his or her individual strategies. Although the sleep-management plan is tailored to the individual, the controls generally are applied to small groups of soldiers. For example, sound masking, a technique to help soldiers sleep in a noisy environment, benefits all soldiers trying to sleep in the immediate area. Thus, there are individual and small-unit responsibilities involved in implementing a sleep-management plan.

■ **Light-management plan.** The light-management plan provides specific instructions regarding when to avoid or seek daylight exposure. This plan is designed to enhance speedy adaptation to a new work schedule and/or time zone.

- **General controls.**
  - Sleep must always take place in darkness. Encourage personnel to wear sleep masks while sleeping.
  - Urge soldiers to avoid variation in the timing of initial daylight exposure after awakening. Frequent variations of more than 3 hours from day to day are likely to induce maladaptation.
  - Soldiers shifting to a day-oriented work schedule should seek as much daylight exposure as possible.
  - Tried and true techniques such as blacking out windows to exclude light and using sleep masks should be used whenever practical.
- **Night operations.**
  - During transition to night operations, it is best to avoid early morning daylight from sunrise to wake-up time. Daylight exposure should take place approximately 8 hours from bedtime. Thus, wake-up time must be adjusted to accommodate the 8 hours in darkness.
  - On days when early morning daylight exposure cannot be avoided, dark sunglasses can be used to reduce the amount of light reaching the eyes. Retiring as soon as possible is important because sleep quality decays as bedtime occurs later in the morning.
- **Travel across time zones.**
  - The body's biological clock remains in the origination time zone until the daylight exposure schedule begins the process of readaptation.
  - The first 3 days in the new time zone are critical. Daylight schedules prescribing exposure or avoidance must be followed as closely as possible. See appendix F for specific schedules.

■ **Controlling the environment.** Noise and daylight intrusions into sleeping quarters must be controlled as much as possible, particularly when soldiers are sleeping in the field. Similarly, controlling extreme temperatures in sleeping quarters will promote high-quality sleep. Following are some practical environmental controls:

- Reduce disruptive environmental noise during the sleep period by using sound masking. Good sources of masking sound are fans, generators, or commercially available devices that produce rushing sound.
- Use battery-powered individual plastic fans in hot environments.
- Use sleep masks when tent flaps must be raised on hot days, opening the tent to ambient daylight.
- On cold winter days, avoid keeping heaters on during the sleep period by warming the tent prior to bedtime. If temperatures can be tolerated, this strategy will avoid disruption of sleep due to fire-guard-duty schedules.

UNIT-LEVEL ELEMENTS

■ **Briefing schedules.** In the deployment setting, sleep is frequently disturbed or delayed by numerous mandatory briefings scheduled during the designated sleep period. With proper planning and command emphasis, many of these briefings can be scheduled to occur outside of the designated sleep period.

■ **Training schedules.** Training schedules can disrupt a well-planned crew-rest strategy. It is imperative that the S3 be kept well informed of unit schedules so that necessary training can occur without interfering with crew rest. Allowances can be made to allow night operations personnel to participate in training activities outside the designated sleep period.

■ **Meal schedules.** Just as badly scheduled training can disrupt crew rest, so can meal service. Meals must be provided so that scheduled sleep periods are not disturbed and should also be shifted to match the new sleep/wake cycle. That is, the first meal upon awakening should be breakfast, regardless of when that meal occurs. Planners should maintain close coordination with the S4 by providing the details of crew-rest plans that will require scheduling of meals outside the normal schedule.

MATERIEL-LEVEL ELEMENTS

■ **Aircraft management.** This unit activity involves the scheduling and execution of activities associated with the operation of aircraft. This includes scheduling of maintenance, refueling, aircrews, and aircraft. Each of these activities may potentially disrupt the crew-rest plan if coordination is neglected.

- **Maintenance.**
  - ◆ Coordinate an effective maintenance network to provide support for crews who must retire prior to mandatory maintenance being completed in order to comply with crew-rest guidelines.
  - ◆ A maintenance schedule and network must be designed to allow aircrewmembers to submit maintenance requests after arrival from night missions. This prevents responsible personnel from having to break crew rest to submit paperwork or carry out maintenance. Coordination with S3, S4, and Tactical Operations Center (TOC) personnel will be necessary to ensure the effectiveness of this plan.

- **Refueling schedules.** Depending on the tactical layout, there will be times when aircraft are parked near troop tents. In such cases, refueling should be coordinated to take place outside of the sleep period to avoid disturbing sleeping soldiers with noise from fuel trucks and other disruptions.

- **Aircraft scheduling.** Rather than allowing individual pilots and crew chiefs to maintain aircraft keys and log books, attempt to keep these items in a ready tent. This will prevent unnecessary disruption of crew rest when the need arises to borrow an aircraft or fly a maintenance test flight and so forth. Scheduling the aircraft for the daytime mission may involve the nighttime crews if logbooks and keys are not readily available.

- **Airspace management.**
  - ◆ When positioning aviation units in the field, it is important to segregate day crews from night crews as much as possible to reduce ambient noise levels during scheduled sleep periods.
  - ◆ Ensure that approach routes into field landing zones/bivouac areas do not overfly designated sleep areas.
  - ◆ Unit operations should direct visiting aircraft to landing areas that are not immediately adjacent to sleeping soldiers.

DESIGNING THE CREW-REST PLAN

Formulating the crew-rest plan requires an understanding of mission objectives and the flight schedules supporting the accomplishment of each objective. Other critical unit activities previously outlined also must be identified, such as maintenance schedules, briefing schedules, training schedules, and special-duty schedules (e.g., guard duty, KP, etc.). Then taking into account all elements of the model, a sleep- and daylight-exposure-management plan can be designed.

Sleep management implies the identification of bedtimes and wake-up times that are likely to provide sufficient rest and return soldiers to duty with maximum alertness. The daylight-exposure-management plan provides a schedule of daylight avoidance/exposure that will maintain the body clock synchronized to the mission-driven work/rest cycle. Both plans are dependent on mission objectives (center of model). Unit-level elements such as training and meal schedules should be adjusted to the individual-level sleep and daylight-management plans. Materiel components should be adjusted to fit the coordination worked out for individual and unit levels.

The crew-rest plan must be designed with basic information in mind relating to flight schedules, sleep, daylight exposure, environmental factors, unit, and materiel elements. The following example provides details on critical elements of each of the three levels of the crew-rest model with the aim to facilitate the designers' task.

Example. An Army aviation unit that is acclimated to daytime flight missions receives orders to participate in insertion and extraction of troops from 2000 to 0200 hours for 7 consecutive days.

Individual level

■ **Sleep management.** Schedule sleep between 0200 and 1000. Observe bedtime and wake-up time even on nights off. Do not change the sleep schedule but do accommodate leisure activities.

■ **Light management.** Avoid daylight from dawn to 1000 (if mission extends past expected schedule). Wear a sleep mask on summer days when daylight intrusions into the tent are more likely to occur. Sleep in the dark. Wear sunglasses outdoors during the daylight avoidance period as long as safety is not compromised.

■ **Controlling the environment.** Use sound masking in tents or use a generator to provide masking sound to avoid disruption of the sleep period.

Unit level

■ Coordinate tactical field layout prior to deployment. In the layout try to separate night and daytime crews by at least 1 to 2 km when in tents. Where possible, house crews in separate buildings when in garrison.

■ Choose a tactical layout that will allow separation of personnel. For instance, a crescent-shaped layout will allow troops in tents to be separated if they are placed in the outer ridge. In contrast, a circular layout may be less desirable because tents will tend to be placed closer to each other.

■ Meal times: provide breakfast at 1000 (hot food brought to field location). Lunch and dinner same as daytime schedules.

■ Schedule an update briefing (e.g., weather, battle status, new operational orders) for night crews approximately 1 hour after lunch. Alertness level may be low during the first 3 days of transitioning to the new work schedule. However after adaptation, alertness should begin to improve in the afternoon hours as the body clock readjusts to an evening orientation.

Materiel level

■ Depending on the tactical layout, it will be important to schedule aircraft refueling well after 1000, thus allowing crewmembers to take full advantage of their sleep period without disruptions.

■ Because crew chiefs will be returning from missions after maintenance personnel have retired for the day, it will be necessary to coordinate a network for maintenance requests with TOC personnel. Crew chiefs should be able to turn in maintenance requests to the TOC upon arrival. The TOC should then forward the requests as soon as maintenance personnel are back on duty.

■ Set up a ready tent for aircraft logbooks, keys, and field phone. This will prevent disruption of the sleep period when an aircraft must be rescheduled for a daytime mission. A variation on this recommendation is to simply turn in logbooks and keys to the TOC after return from each mission.

For more information on crew-rest and light-management plans, contact Dr. Carlos A. Comperatore at the United States Army Aeromedical Research Laboratory, Aeromedical Factors Branch, DSN 558-6858 (334-255-6858).

Appendix A

Fatigue

TYPES OF FATIGUE

Fatigue can be classified as either acute or chronic; the focus of this guide is acute fatigue.

■ **Acute fatigue** results from short periods of heavy physical or mental demands or from short-term sleep loss. The effects of acute fatigue are of short duration and usually can be reversed by sleep and relaxation.

■ **Chronic fatigue** takes longer to develop than acute fatigue and can be difficult to treat. It usually results from several bouts with acute fatigue. Frequently there are social problems that contribute to chronic fatigue (financial, marital, or other difficulties), and actual depression may ensue. Because it takes longer to develop and has many contributing factors, it may take weeks for the effects of chronic fatigue to subside.

Unit morale is an important factor to consider when assessing chronic fatigue. Although acute fatigue is the most immediate problem, leaders should keep in mind the cumulative effects of social stressors and unit stressors (e.g., tempo, combat, fatigue) on morale and safety. Chronic fatigue may be lurking behind the scenes.

CAUSES

Fatigue has both physical and mental components:

■ **Physical or physiological fatigue** can be described as the temporary loss of the ability to respond due to repeated or continuous stimulation of the muscles (e.g., during strenuous exercise). Thus, soldiers can suffer from physiological fatigue as a result of engaging in intense physical work. Some other causes of physiological fatigue include:

- Sleep loss.
- Noisy or hot environments.
- Inadequate nutrition and fluids.
- Hypoxia.
- Poor physical conditioning.
- Sudden changes in work/rest schedules.

■ **Mental fatigue** or boredom is the feeling of weariness that results from repetitive performance of nonphysical tasks. Soldiers can be affected after only a few minutes of performing monotonous work. Repetitive performance of even fairly complex tasks can result in mental fatigue. Mental fatigue can also be caused or made worse by anxiety, apprehension, and stress.

The severity of fatigue can be modified by such psychological factors as expectancy. The amount of time soldiers expect to be working, the anticipated difficulty of the work, the expected reward, and other variables will affect the severity of fatigue-induced performance changes.

FATIGUE CHARACTERISTICS

Fatigue levels tend to be higher at the midpoint and toward the end of a work shift than at other times during the day. In industry, accidents peak during the last 2 hours of 10-hour days, presumably because of fatigue. Generally, alertness declines sharply from 1600 to 2300 during a normal day, and after 2300 the probability that people will lapse into sleep increases dramatically. Otherwise normally-functioning soldiers may suffer from short, intermittent episodes of fatigue, especially when sleep deprived. These episodes are characterized by very brief lapses in the performance of tasks during which details are missed, accuracy is impaired, and/or performance is slowed.

Appendix B

Sleep Management

SLEEP CYCLES

Sleep is an active process, with a defined cycle of activity that progresses predictably throughout the sleep period (see figure 2). The brain activity that occurs during sleep is measured in five stages:

Stage 1 is the transition from wake to sleep. This stage is characterized by a slowing of brain activity compared to wakefulness. When aroused from this stage, many people believe they were never asleep. After about 5 to 10 minutes of stage 1 sleep, the person progresses to a deeper sleep, stage 2.

Stage 2 is characterized by even slower brain activity than stage 1 and is considered by many to be the true onset of sleep. Within 10 to 15 minutes, brain activity slows down even further and progresses into the deepest sleep, stages 3 and 4.

Stages 3 and 4 are termed slow-wave sleep (SWS). It may be very difficult to arouse a person from SWS, and once awake, the person may feel sluggish for several minutes. After 20 to 30 minutes of slow-wave sleep, brain activity reverts briefly back to stage-2 sleep, and is then followed by rapid eye movement (REM) sleep, or dream sleep.

Stage 5, REM or dream sleep, is characterized by quick eye movements, little to no muscle tone, and very active brain patterns. The first REM period of the night is relatively short, lasting 5 to 10 minutes.

After REM sleep, the sleep cycle repeats itself, returning to stages 2, 3, 4, and back to REM. Each cycle lasts approximately 90 minutes, with approximately five to six cycles occurring per night. Most SWS occurs during the first half of the sleep period, while most REM sleep occurs during the second half of the period. Overall, stage 2 sleep occupies the majority of the sleep period, followed by REM sleep, and then SWS.

This cycle of sleep activity is important for soldiers to acquire restful sleep. The cycle can be disrupted by schedule changes, frequent awakenings, medications, and so forth. When a significant disruption in this pattern occurs, soldiers may not obtain restful sleep and will be fatigued the next day.

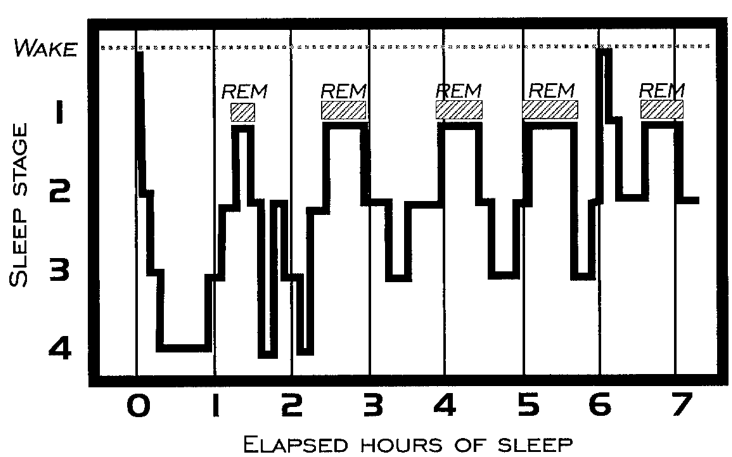


Figure 2: Typical sleep cycle of REM, non-REM sleep

EVERYDAY SLEEP MANAGEMENT

Many times the ability to achieve good quality sleep depends on good sleep habits. It is unwise to become dependent on sleep medications for a variety of reasons, and when one adheres to some commonsense behavioral strategies for sleep, sleep aids may not be necessary except in extreme situations.

Leaders and soldiers should be aware of the following factors that can affect ability to sleep and the quality of sleep achieved.

Planning for sleep

■ The amount of sleep each person needs varies; one cannot gauge individual sleep needs from what other people require.

■ Try to sleep at the same time every day, including weekends. If possible, go to bed at the same time and get up at the same time each day.

■ If a sleep aid was taken previously, the first and possibly the second night of sleep without medication may be disrupted. Falling asleep may be delayed, and the person may awaken several times during the night. However, this will subside within 1 to 2 nights.

■ Avoid eating or drinking substances that contain caffeine (coffee, tea, chocolate) 4 to 5 hours before bedtime.

■ Alcohol should never be used to aid sleep. Although sleep onset may come more quickly after ingestion of alcohol, it is more disrupted and less restful after the first 1 to 2 hours of sleep.

■ Do physical training no closer than 1 hour before bedtime since exercise has a temporary alerting effect.

Good sleep habits

■ When trying to sleep outside the usual sleep period (e.g., during the day), prepare as if it is the normal sleep period—wear normal sleep clothes, darken the room as much as possible, keep noise to a minimum, and use a white-noise generator, such as a fan, if possible.

■ Use bed only as a place to sleep; do not read, work, or do other similar activities in bed. Associating bed with sleep will eventually allow sleep to come more easily.

■ After 24 to 48 hours of sleep deprivation, do not sleep overly long during the recovery period (more than 10 hours). Sleeping too long may interfere with the normal sleep/wake schedule and will cause significant sleep inertia and lethargy during the day. The normal sleep period for an individual is usually sufficient to recover from 24 hours of sleep deprivation.

Problems with sleep

■ If you cannot fall asleep after about 30 minutes in bed, do not remain in bed awake; get up to avoid associations of waking and anxiety with bed. Stay up several minutes and then try again. Continue to get up if you cannot go to sleep within 30 minutes, no matter how many times this may occur during the sleep period. Eventually, fatigue will take over.

■ A person who has difficulty sleeping during the normal sleep period should not nap during the day; this may delay sleep onset during the regular sleep period.

Appendix C

Pharmacological Sleep Aids

In some situations, soldiers may have an opportunity to sleep but be unable do so because of time-of-day effects, anxiety, noise, heat, etc. The use of sleep aids (sedatives) is an option commanders may want to consider in these cases. The flight surgeon can recommend which sleep aid to use in each particular situation. The following information will give planners and commanders a basic familiarity with the flight surgeon's options.

The *barbiturates*, popular sleep aids during the 50s and 60s, have generally been replaced by two newer agents belonging to the benzodiazepine class, *temazepam (Restoril™)* and *triazolam (Halcion™)*. These agents have been used successfully in the aviation environment.

- Triazolam's short half-life* allows for operational flexibility.
- Temazepam has fewer side effects than triazolam and has few residual effects following an 8-hour sleep period.

A new nonbenzodiazepine agent, *zolpidem (Ambien™)* has a short half-life and low incidence of side effects. Zolpidem has recently been approved for use by aviators after proper command approval.

ADMINISTRATION GUIDANCE

Sleep aids should be used cautiously in the operational environment and as a method of last choice. The choice of a sleep aid for use by soldiers will depend upon the operational situation. Factors to consider include availability, duration of action, and the incidence of side effects such as amnesia and sleep inertia. The following guidance should be considered:

- Side effects (short-term memory and amnesia), which can be dangerous in a military environment, can occur after the use of any sleep aid.

- Residual effects may compromise performance, especially if the soldier is awakened shortly after the drug is taken.

- After using sleep aids for several consecutive days, sleep on the first night following discontinuation of the medication may be disrupted, including difficulty falling asleep and awakening several times during the night. This effect should be taken into account when planning work/rest schedules.

- Sleep aids can be used to induce sleep during a time-zone change or a change in work hours (night shift work), but these drugs do not "reset" the body clock. The circadian rhythms remain disrupted until the soldier has had time to readjust to his or her new sleep/wake cycle (see appendix F).

- Many side effects of sleep aids are worse if accompanied by the use of alcohol.

- All drugs considered for use in the operational setting should be pre-tested on potential recipients by the flight surgeon under controlled conditions to ensure that adverse reactions do not occur.

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*Half-life is the time required for the body to eliminate one-half of the initial dose. A half-life of 4 hours means that half of the drug will be eliminated from the body after 4 hours.

■ There may be individual differences in the duration of sleep inertia after taking these drugs. Soldiers who are asked to function within two half-lives of the ingested medication (see table 2) should be carefully observed for sleep-inertia effects.

■ As with any medication, aviators must adhere to the flight surgeon's grounding guidelines (see table 2).

Table 2: Sedative Medications

NAME	USUAL DOSE	HALF LIFE*/ GROUNDING TIME (GT)†	PROS	CONS	COMMENTS
TEMAZEPAM‡	15-30MG	10-17HRS GT: 12HRS	- MEDIUM DURATION - USED IN MILITARY ENVIRONMENT SUCCESSFULLY - FEW SIDE EFFECTS	- MILD HANGOVER POSSIBLE	- BRAND NAME RESTORIL™ - HAS BEEN APPROVED FOR ARMY AVIATORS IN PAST
TRIAZOLAM‡	.125-.25MG	1.5-3HRS GT: 12HRS	- SHORT ACTION - USED IN MILITARY ENVIRONMENT SUCCESSFULLY - FEW SIDE EFFECTS	- OCCASIONAL AMNESIA WITH HIGHER DOSE	- BRAND NAME HALCION™ - HAS BEEN APPROVED FOR ARMY AVIATORS IN PAST
ZOLPIDEM	10MG	1.4-4.5HRS GT: 12HRS	- SHORT ACTION - FREE OF SIDE EFFECTS	- EXPENSIVE - NEW DRUG	- BRAND NAME AMBIEN™ - NEW DRUG IN U.S. - RECENTLY APPROVED FOR ARMY AVIATORS

*HALF-LIFE IS THE TIME REQUIRED FOR THE BODY TO ELIMINATE ONE-HALF OF THE INITIAL DOSE. A HALF-LIFE OF 4 HOURS MEANS THAT HALF OF THE DRUG WILL BE ELIMINATED FROM THE BODY AFTER 4 HOURS.

†REFERENCE ARMY POLICY LETTER (APL) 9-89.

‡ONLY TEMAZEPAM AND TRIAZOLAM HAVE BEEN USED IN ACTUAL OPERATIONS. THE GROUNDING TIME FOR TRIAZOLAM WAS 6 HOURS, AND THE GROUNDING TIME FOR TEMAZEPAM WAS 8 HOURS. HOWEVER, THESE TIMES WERE APPROVED ONLY DURING OPERATIONS DESERT SHIELD/DESERT STORM AND WILL REQUIRE REVISION OF POLICY FOR FUTURE USES. TEMAZEPAM CAN BE USED DURING PEACETIME WITH A GROUNDING PERIOD OF 12 HOURS.

Appendix D

Napping

If the pace of operations or the available staffing level permits, naps can be used to sustain performance during the continuous work period. During continuous operations (CONOPS), leaders should encourage preventive napping; allow time and provide a quiet, comfortable place for short naps as the mission permits; educate soldiers about the benefits of napping; and inform them that rest is no substitute for sleep. Napping during CONOPS will reduce performance impairment but will not totally alleviate effects of sleep deprivation. Individual differences in sleep needs must be considered in determining nap length. Several factors are important to consider when scheduling naps:

- **Pre-existing amount of sleep loss**
  - The best time to nap is before significant sleep loss has occurred. These naps will help prevent subsequent performance impairment during continuous work schedules. Soldiers who nap for 1 to 4 hours prior to a night work period will show improved subsequent early morning performance and alertness above those who do not nap. Preventive napping may be better than a nap during the sleep-deprivation period.
  - Naps do not totally eliminate the normal circadian dip experienced in the early morning around 0500, but the degradation in both cognitive performance and alertness is reduced.

- **Nap length**
  - Naps should be as long as possible.
  - A single 2-hour nap during a 24-hour continuous work period can restore performance close to pre-sleep-loss levels.
  - If longer naps are not possible, several naps of as little as 10 minutes each taken over a 24-hour period can help soldiers endure CONOPS.

- **Timing of the nap**
  - It will be easier for soldiers to nap when core body temperature is at its trough (around 0300 and 1300) and more difficult when at its peak (around 1500).
  - Post-nap sleepiness is higher and performance lower for several hours when a soldier is awakened from a nap during the circadian trough as compared to awakening from a nap taken during the circadian peak.
  - Early morning naps (0200 to 0600) are beneficial in restoring alertness and performance, but time should be allowed for soldiers to fully recover from the nap.

- **Length of time between end of nap and work period**
  - Performance is generally lowest during the first 5 minutes after awakening (sleep inertia), but usually recovers after 15 to 30 minutes.
  - Extensive sleep inertia is especially likely when one is awakened from slow-wave sleep, which occurs most often within the first 2 hours of sleep.
  - Awakening from sleep that follows a long period of sleep deprivation leads to high levels of sleep inertia; the longer the sleep-deprivation period, the higher the sleep inertia.
  - During CONOPS when a soldier must return to work immediately upon awakening, naps in the circadian trough should be avoided because sleep inertia will be high.

Appendix E

Pharmacological Stimulants

In some extreme "fly or die" operational situations, behavioral countermeasures and the use of naps alone may not maintain performance at the desired level. When the reversal of acute fatigue is critically important, stimulants may be useful. Stimulants have been used by the military since World War II, but there have been few controlled field studies. The decision to use stimulants requires close coordination by the unit commander, planners, safety officer, and flight surgeon. A brief review of the major stimulant drugs follows.

Caffeine is readily available, socially acceptable, and relatively safe. Caffeine significantly enhances both subjective and objective measures of alertness, but the performance effects of caffeine are variable. Large doses of caffeine (the amount found in three to six cups of coffee) can temporarily reverse the performance decrements that follow 48 hours of continuous wakefulness. Smaller doses of caffeine can help to counteract shorter deprivation periods, especially when used judiciously (i.e., immediately prior to the performance period). The effects of caffeine last 4 to 6 hours after it is ingested. Soldiers should be discouraged from drinking large amounts of caffeinated beverages continuously during sustained operations (SUSOPS) because they will quickly adapt to the effects of caffeine, and the substance will no longer maintain alertness. Frequently reported side effects after caffeine ingestion include anxiety, tremor, frequent urination, and upset stomach, especially in persons who do not normally consume caffeine. These problems may interfere with performance even though alertness has been improved.

Heavy caffeine users develop tolerance quickly, so that much larger doses will be necessary to produce a consistent alerting effect. Sudden withdrawal of caffeine from heavy caffeine users (those consuming more than four or five cups of coffee per day or eight 12-ounce servings of caffeinated beverages) can produce adverse effects on performance and mood and often results in headaches and other undesirable physical symptoms. Individuals with heart problems or high blood pressure should generally avoid caffeine.

Controlled drugs. The following drugs are available by prescription only and are considered controlled substances by the Food and Drug Administration due to their high addiction and abuse potential. Their use should be considered only in extreme "fly or die" combat scenarios and must be authorized by the chain of command.

Methylphenidate (Ritalin™) and **pemoline (Cylert™)** may offer advantages over caffeine, although systematic comparisons have not been performed. Methylphenidate is a mild brain stimulant that exerts most of its effects on mental activities. Methylphenidate and Pemoline elicit relatively infrequent cardiovascular side effects. Both drugs can reverse the effects of fatigue on performance although their effects on mood are debatable. Pemoline has the potential advantage of a longer duration of action than methylphenidate. These drugs have not been approved for use by aviators.

Dextroamphetamine (Dexedrine™). The most widely studied stimulant, and the one with the clearest evidence of efficacy (i.e., the most powerful), is amphetamine, especially dextroamphetamine (Dexedrine™). Numerous laboratory investigations have shown that amphetamines are capable of recovering the performance of personnel who have been fatigued or significantly sleep deprived. Also, preventive administration of dextroamphetamine can prevent many of the performance decrements attributable to sleep loss.

The benefits of employing amphetamines include—

- Effective maintenance of alertness and performance for several hours at relatively low doses.
- A low incidence of tremor, anxiety, or gastrointestinal disturbances.
- Demonstrated effectiveness in actual military operations.

On the other hand, the drawbacks of using amphetamines are:

- They are highly addictive.
- The dosage must be increased frequently to derive equivalent drug effects if the drug is given continuously for several days or weeks.
- They can be lethal at only 4 to 5 times the recommended dose (approximately 70 mg).
- They produce cardiovascular side effects (increased heart rate and blood pressure).

Methamphetamine (Desoxyn™) has sometimes been used instead of dextroamphetamine because it has greater alerting effects with fewer cardiovascular effects. Methamphetamine also has a shorter half-life (4 to 5 hours vs. 10 hours) but may be more difficult to obtain than dextroamphetamine.

ADMINISTRATION GUIDANCE

The choice of which stimulant is most appropriate for specific operational problems will be made by the flight surgeon in consultation with planners and leaders. Gaining authorization from the chain-of-command prior to the use of controlled substances is essential. Drug availability may be a concern along with other factors such as the magnitude and duration of drug effects, time of day the drug is administered, potential for abuse, or other problems. However, generally speaking, the following guidance should be considered:

- Stimulants should be administered at least 1 hour before critical performance periods because it takes time to obtain the peak drug effect.
- Mild sleep deprivation can be counteracted with large doses of caffeine or small doses of amphetamine, but amphetamines in relatively large doses will be required if soldiers have gone 24 hours or more without sleep.
- Lower doses of stimulants will be required during daytime than during nighttime work periods.
- The last dose of any stimulant should be given far enough in advance of the scheduled sleep period for drug effects to dissipate or sleep will be disrupted. Avoid using hypnotics to induce sleep in soldiers who have been kept awake on stimulants (and vice versa).
- Stimulants are only a temporary solution—the need for sleep cannot be postponed indefinitely.
- Tolerance to stimulants develops quickly, so it will be necessary to increase the drug dosage after repeated exposure in order to derive consistent benefits.
- All drugs contemplated for use in the operational setting should be pre-tested on potential recipients under controlled conditions to ensure that adverse reactions do not occur.

Table 3: Stimulant Medications

NAME	USUAL DOSE	HALF LIFE*	PROS	CONS	COMMENTS
Caffeine	200-400mg every 4 hrs	4-5 hrs	- plentiful - legal - user acceptance	- marginally effective - tolerance exists - side effects (tremor, diarrhea, diuretic)	- avoid in soldiers with heart problems and/or high blood pressure
Dextroam-phetamine†	5-10mg every 4-6 hrs	10 hrs	- effective - extensively studied	- occasional amnesia with higher dose	- brand name Dexedrine™ - has been approved for Army aviators in past

*Half-life is the time required for the body to eliminate one-half of the initial dose. A half-life of 4 hours means that half the drug will be eliminated from the body after 4 hours.

†Dextroamphetamine is available in some extreme "fly or die" operational situations (see first paragraph of this appendix).

Appendix F

Circadian Rhythms

PHYSIOLOGY

A day-oriented body clock controls specific patterns of hormones, alertness, and core body temperature. The word circadian (Latin: circa = about; dies = day) is used to describe biological and behavioral rhythms regulated by the body clock.

Figure 3 depicts the relationship between the hormone melatonin, the light/dark cycle, core body temperature, and alertness. Melatonin is a hormone produced during the night that regulates sleep and the timing of the body clock. Alertness is in phase with core body temperature and inversely related with melatonin levels. As a person transitions from daytime to nighttime work, the body clock provides mental and physical energy during the day, but not during the night. This energy cycle will be stable and predictable only if the body clock receives daylight exposure at consistent times from day to day.

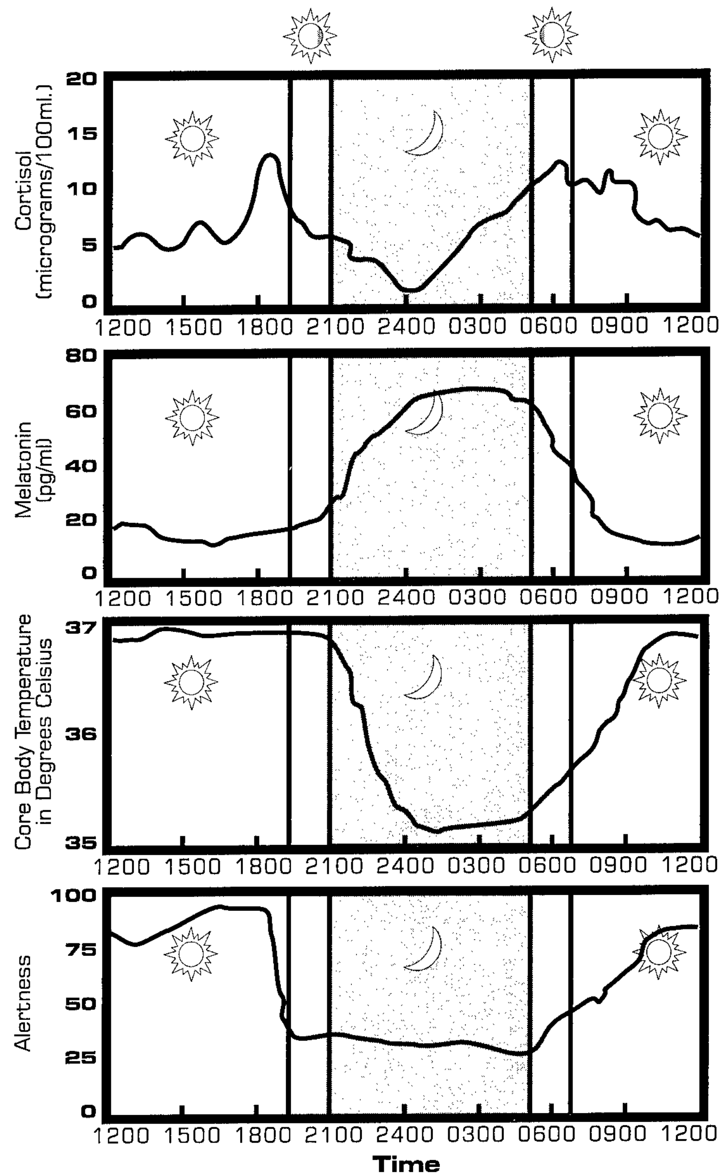


Figure 3. Twenty-four-hour body rhythms

CONSEQUENCES OF DESYNCHRONOSIS

Studies of the performance of night-shift workers and long-distance travelers show a consistent reduction in work efficiency, and in some cases, safety. The following list summarizes a few specific work-related consequences due to jet lag or shift lag:

- Truck drivers have been shown to have twice as many accidents between 2400 and 0200 compared to during the day.
- Locomotive operators have an increased probability of missing warning signals when working the night shift.
- Night-shift workers perform worse on tasks of vigilance and reaction times when compared to day workers.
- Aviators flying in flight simulators at night have reduced hand-eye coordination, poorer vigilance and calculation proficiency, and impaired flight performance compared to day fliers.

DESYNCHRONOSIS CONTROLS

The following list of recommendations should be helpful in the prevention of circadian maladaptation or desynchronosis. Once shift lag or jet lag actually develops, returning to normal can take several weeks of a consistent sleep/wake schedule. Desynchronosis symptoms are unlikely to disappear in just a few days of normal sleep. These general recommendations can be used by individual unit members and staff personnel planning work and briefing schedules.

General recommendations.

■ Maintain consistent schedules in the timing of sleep, wake-up, daylight exposure, and naps after arrival in the new time zone and/or shiftwork transitions.

■ Avoid changing sleep/wake schedules during days off.

■ Always sleep in completely darkened rooms. If sleep must occur under daylight, wear a black cloth sleep mask.

■ Strive to sleep at least 6 continuous hours per day.

■ Become aware of how many hours of sleep you need to feel refreshed and alert upon awakening. Short sleepers may need as little as 5 hours, long sleepers as many as 8 hours.

■ If after sleeping, you feel very sleepy during the afternoon hours, you need more sleep.

■ Prevent noise from disrupting the sleep period. Use masking noise (e.g., the noise of a fan, a power generator, or commercially available sound-masking devices), or wear foam earplugs.

■ Avoid meals of high-fat content for at least 3 days after the transition to the new location or work schedule. Gastrointestinal disorders can surface while readjusting to a new time zone and/or work schedule.

Napping and circadian desynchronosis.* In the context of body-clock adjustment, naps are recommended if—

■ You rotate from day to night shift, and

■ You cannot sleep more than 4 to 5 hours during the sleep period, and

■ The next night is going to be another work period.

- Naps longer than 1 hour are not recommended if your next sleep period will take place during the following night. In this case, naps taken during the day may interfere with the onset and duration of that night's sleep.

- When rapid shift rotations are used, soldiers should be encouraged to use naps during time off to compensate for sleep loss incurred during the transition to nighttime duty hours.

- When shifting from daytime to nighttime duty hours, opportunities for naps may occur—
  - ◆ During the afternoon (e.g., 1500 to 1700 hours).
  - ◆ In the evening prior to reporting (e.g., 1600 to 1900 hours) for the duty period (e.g., work period from 2100 to 0500 hours).

- Research on the effects of the restorative value of naps indicates that—
  - ◆ A 2-hour nap taken in midafternoon (e.g., 1500 hours) resulted in greater restoration of alertness than a 2-hour nap taken in the evening (e.g., 1900 hours).
  - ◆ Naps taken during the midafternoon (1500 hours) contain more total dreaming time (REM sleep) than naps taken at 0300 hours.
  - ◆ When transitioning from daytime to nighttime duty hours later that day, a nap at 1500 hours may well compensate for sleep loss incurred during the assigned sleep period.
  - ◆ Naps taken in the afternoon may be more restorative than naps taken in the evening, before reporting for duty. Naps taken during the work period after midnight, however, may not only be less

*For a more extensive discussion of napping, see appendix D.

restorative than earlier naps, but may also induce sleepiness upon awakening and performance degradation for up to 1 hour. This consideration limits the value of a nap after midnight.

Pre-adaptation. Prior to deployment, a unit can attempt to pre-adapt to the new work shift or destination time zone. While potentially useful, pre-adaptation requires much coordination and cooperation from all levels of the involved unit. In a pre-adaptation scenario, deploying elements typically begin shifting their sleep-wake cycle from origination time (OT) toward the new sleep/wake cycle several days before transition.

- The number of days devoted to pre-adaptation and the number of hours shifted daily will depend on many factors, including the number of time zones to be crossed and amount of advance notice received.
- The magnitude of the phase shift should not exceed 6 hours per day and preferably should range from 2 to 4 hours per day.
- Sufficient support must be provided to allow pre-adapting soldiers access to finance and personnel services, properly timed meals, and so forth, or soldiers will be unable to follow the adaptation schedule.
- Family members must be educated regarding the pre-adaptation plan so that they support the soldier's changing sleep/wake cycle.
- Under some circumstances, pre-adaptation is particularly difficult—these circumstances are identified in the discussion of specific deployment scenarios later in this appendix.

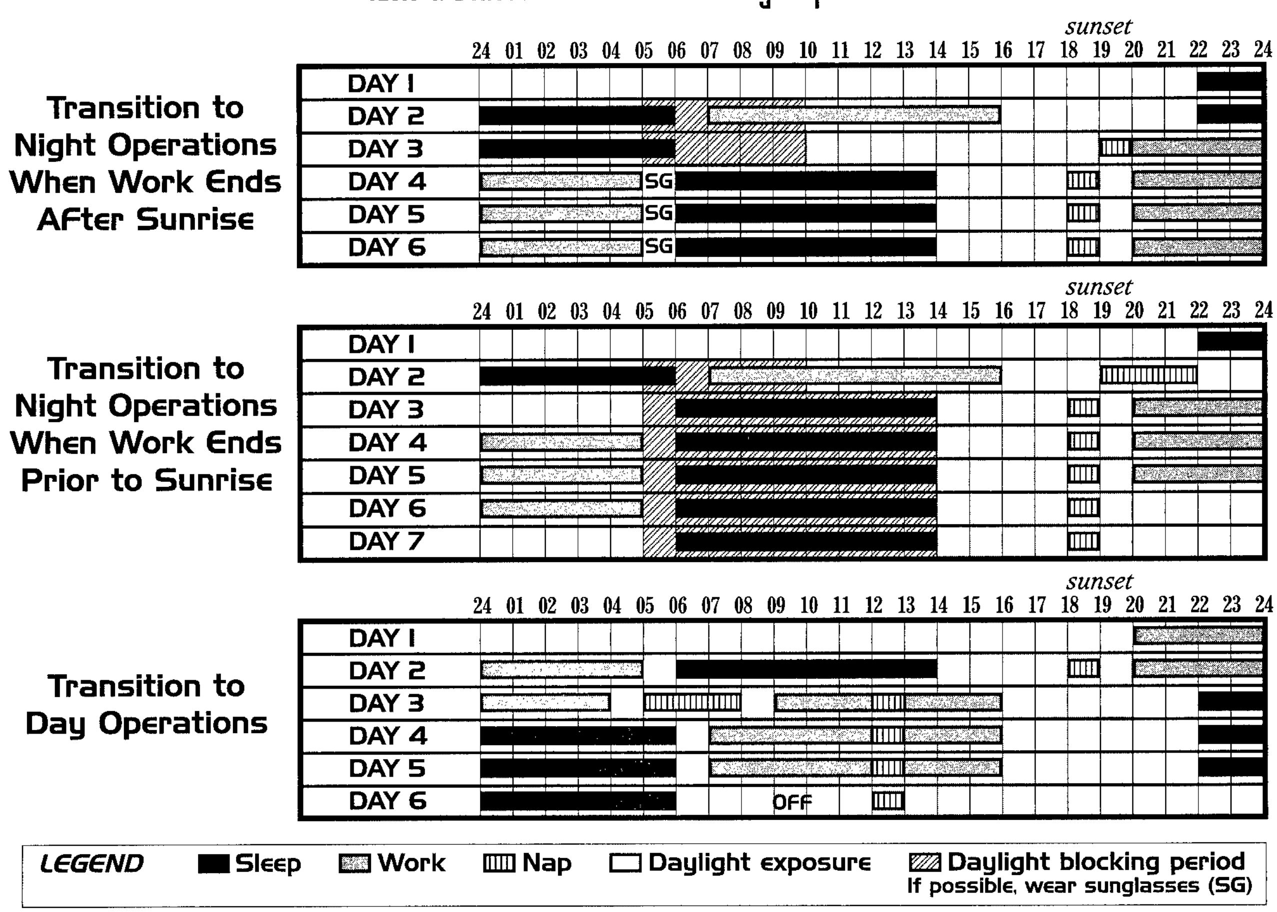
Timed light exposure. The timing of daylight exposure is critical for the resynchronization of the body's biological clock. By carefully scheduling exposure to daylight or proper artificial light, it is possible to speed adaptation to a new work schedule and/or time zone. Specific suggestions are included in the scenarios provided later in this appendix; however, the following general guidelines apply:

- Illuminance levels of above 2500 lux (dawn brightness) are necessary to affect the body's timing mechanism. Exposures lasting at least 1 hour are effective in resynchronizing the sleep/wake cycle and other physiological rhythms.
- For individuals who are accustomed to sleeping during the night, working during the day, and retiring at or about 2200, daylight or sufficiently bright light exposure between 0300 and 0700 OT (the advance body time zone) will consistently advance sleep onset approximately 1 to 3 hours earlier per day. Predicting the exact amount of the advance requires information on physiological rhythms that will be impractical to obtain in most applied field situations.
- In eastward travel, seeking daylight exposure during the advance body time zone for the first 3 days will speed the resynchronization process. The advance zone will shift to earlier times from day to day, and it is difficult to accurately predict the time range after 2 days of advances without data on physiological rhythms. Therefore after the third day, daylight exposure should be coordinated to occur as soon after awakening as it was in the OT zone.
- In westward travel, seeking daylight or bright light exposure between 2000 and 0300 will help delay sleep onset. The duration of the delay depends on the duration of light exposure. In most cases, exposure durations of 1 to 3 hours will result in a corresponding delay of sleep onset.
- Artificial bright lights can be used to influence these changes in sleep prior to or during shift changes or deployments, provided that the appropriate equipment is available. Bright light banks and visors are available from commercial suppliers and appear to be effective. Providing a brightly lit work area for night-shifters may be of benefit.
- Unwanted exposure to daylight may be minimized by wearing dark sunglasses. Very dark sunglasses may be ordered from commercial sources. If these are not available, conventional sunglasses should measurably reduce light exposure.

CONTROLS FOR NIGHT OPERATIONS/SHIFTWORK

Recommended night shift transition schedules (table 4). This table suggests work-sleep-nap schedules to assist planners during a transition to and from night operations. To use the table, first determine which of the three sections applies to your upcoming transition. Your current work-rest schedule should approximate the schedule described on Day 1. The hypothetical transitions provided in the table assume a normal work week (Monday through Friday). However, the user should adjust the schedule to fit the mission scenario. The table assumes that you are well adjusted to the initial work schedule (stable for at least 2 weeks). The daylight symbols indicate the time range during which you should attempt to obtain (or avoid) exposure to daylight. Pay close attention to the daylight symbols as they change during duty hour transitions. The word "sunset" indicates that you should be able to seek daylight exposure throughout the day until local sunset. To obtain daylight exposure, you may want to schedule outdoor activities such as exercise or a walk outdoors whenever possible. When naps are indicated, you should try to take a nap that is at least 1 to 2 hours long to compensate for the anticipated sleep debt. Note that in the transition to Day 4, SG indicates that you should avoid daylight until bedtime by wearing sunglasses if necessary. Try to follow the sleep and daylight management schedules as closely as possible.

Table 4: Schedule for Transition to Night Operations



DURING FIRST 3 DAYS OF TRANSITION TO *ANY* NIGHTTIME DUTY WORK SCHEDULE, REDUCE WORK LOAD BETWEEN 0400 AND 0700 TO PREVENT INCREASED RISK DUE TO FATIGUE AND SLEEPINESS. DURING TRANSITION BACK TO DAY SCHEDULE, REDUCE WORKLOAD NEAR THE END OF THE WORK PERIOD (AFTER 1500).

DAYLIGHT EXPOSURE PERIOD MUST BEGIN AT THE EARLIEST TIME INDICATED IN THE TIME RANGE AND END AT THE LATEST TIME. DAYLIGHT EXPOSURE SHOULD LAST AS LONG AS POSSIBLE. NORMAL ACTIVITIES SUCH AS LUNCH AND EXERCISE SHOULD BE SCHEDULED TO OCCUR WITHIN THE TIME RANGE. DAYLIGHT EXPOSURE IS NOT REQUIRED TO OCCUR CONTINUOUSLY; HOWEVER, 2-HOUR EXPOSURES ARE RECOMMENDED.

CONTROLS FOR TRAVEL ACROSS TIME ZONES: SPECIFIC DEPLOYMENT SCENARIOS

Eastward deployment—daytime duty hours. This scenario requires sleep to begin at an earlier time of day, relative to the predeployment time zone (advancing the body clock). Shifting the sleep cycle in an eastward direction is generally considered more difficult than shifting westward. Difficulty falling asleep during travel and upon arrival may be experienced.

■ Adaptation after crossing eight time zones or more may last from 1 to 2 weeks, depending on the observation of the above recommendations and individual physiological makeup.

■ Beginning on the day of travel, daylight exposure should be scheduled to begin between 0300 and 0700 OT. This is the period of time in which daylight exposure helps advance sleep-onset time. On the other hand, exposure to daylight between 2100 and 0200 OT will induce delays in bedtimes and may delay adaptation to the new work/rest schedule (see table 5).

■ The sleep/wake cycle could be adapted to the new time zone several days prior to departure by using bright artificial lights during the early morning hours (0400 to 0700). If bright lights are available (providing at least 2500 lux), expose personnel for a 2-hour period (e.g., from 0400 to 0600) beginning 3 days prior to departure. Pre-adaptation will require soldiers to wake up earlier (relative to OT) as many hours as time zones crossed.

Example. A mission requires daytime flights immediately after rapid deployment eastward across nine time zones. The challenge for the crew-rest planner is to provide countermeasures to prevent jet lag and prepare personnel for mission flights soon after arrival.

■ Sleep onset must be advanced by approximately 8 to 9 hours; therefore, sleep should be scheduled from 2200 to 0600 destination time (DT), or 1300 to 2100 OT.

■ The advance of sleep onset from approximately 2200 OT to 1300 OT (2200 DT) can be facilitated by a daylight-management plan. The planner in this example can consult table 5 for a trip 8 hours eastward and approximate the daylight-exposure period by adding 1 hour to DT clock times. The table indicates the times of day in which exposure to daylight will speed (1100 to 1500 DT) or retard (0800 to 1000 DT) adaptation during the first 3 days in the new time zone.

■ Wearing sunglasses during daylight-avoidance times (0800 to 1000 DT) will be helpful. Special sunglasses that prevent daylight exposure around eyes and reduce illuminance below 2500 lux are available commercially. Thereafter, getting up early in the morning (0600 DT) and seeing daylight throughout the day (e.g., traveling to and from work, during breaks, exercise, lunch, and so forth) will be sufficient to continue the readaptation process.

■ Avoiding daylight during specific times of the day is a requirement for only the first 3 days in the new time zone.

■ Pre-adaptation prior to travel is desirable but very difficult in this case. Since sleep onset must be rescheduled to 1300 OT, it is unlikely that readaptation can take place prior to travel without implementing complicated countermeasures using light schedules indicated by table 5. Light exposure prior to travel will significantly speed the process of adaptation. Daylight avoidance will not be required upon arrival. However, this pre-adaptation may be impractical since it may require sequestering personnel for 2 consecutive days prior to travel (4-hour shift x 2 days) in specially equipped facilities.

■ An alternate method of facilitating the process of adaptation is via sleep deprivation. For example, soldiers can be instructed to stay up all night prior to the day of travel and delay sleep until 1300 OT, provided that travel begins during the morning hours. USAF transport aircrew must be instructed not to disturb passengers sleeping between 1300 and 2100 OT (2200 to 0600 DT). Daylight management upon arrival will contribute to the readaptation process.

■ Planners and commanders should be aware that using sleep deprivation for pre-adaptation may result in sleepiness and degraded alertness during the day of travel and the first day at the destination.

■ To boost alertness during the first week of adaptation to the new time zone, soldiers should be instructed to—

- Change their watches to DT upon boarding the transport aircraft.
- Sleep only during the expected destination sleep period (2200 to 0600 DT).
- Observe the daylight-exposure schedule upon arrival.
- Take short naps (one-half hour) prior to flight missions.

■ If necessary, the flight surgeon may be consulted to prescribe a sleep aid for personnel who have difficulty falling asleep during the advance of the sleep/wake cycle. Mandatory grounding times will be considered before administering any medication to aviators.

Table 5: Light Exposure After Eastward Travel, Daytime Duty*

TIME ZONES CROSSED	DEPLOYMENT DAY	DAYLIGHT EXPOSURE OT	DAYLIGHT EXPOSURE DT	DAYLIGHT AVOIDANCE OT	DAYLIGHT AVOIDANCE DT
4	DAY 1-2	0300-0700	0700-1100	2000-0300	0000-0700
	DAY 3		0700-SS		
6	DAY 1-3	0300-0700	0900-1300	2000-0300	0200-0900
			0700-SS		
8	DAY 1-3	0300-0700	1100-1500	2000-0300	0400-1100
			0700-SS		
10	DAY 1-3	0300-0700	1300-1700	2000-0300	0600-1300
	DAY 4		0700-SS		

*IN THE FIRST COLUMN, IDENTIFY THE NUMBER OF TIME ZONES TO BE CROSSED. THE DAYLIGHT EXPOSURE AND AVOIDANCE SCHEDULES ARE THEN PROVIDED FOR BOTH OT ZONE AND DT ZONE. THIS TABLE ASSUMES THAT THE USER HAS BEEN ON OT FOR AT LEAST 2 WEEKS (I.E., STABLE ON OT).

Eastward deployment—nighttime duty hours. In this case, the body clock may not require a severe shifting since actual sleep and wake-up times will tend to remain in the OT zone. This change may actually require no more than a 4- to 5-hour change in sleep-onset time.

■ Napping (one-half hour) should be encouraged, particularly prior to reporting for nighttime duty hours. After napping, avoid sleep inertia by waking up at least 30 minutes prior to reporting for duty.

■ A caffeinated beverage prior to reporting for duty will help alertness.

Example. A mission requires nighttime flights after rapid deployment eastward across eight time zones. The challenge for the crew-rest planner is to provide countermeasures to prevent jet lag and prepare soldiers for mission flights soon after arrival.

■ Since the mission occurs at night, daylight (or bright artificial light) should be avoided from 0400 DT to bedtime. Bedtime should take place as close to 0400 DT (2000 OT) as possible. Dark sunglasses should be worn when brief exposure to morning daylight (or bright artificial light) is unavoidable. As previously stated, special sunglasses that prevent daylight exposure to the eyes and reduce illuminance below 2500 lux are available commercially. This daylight avoidance should be maintained throughout the mission.

■ Sleep onset must be advanced by approximately 2 to 3 hours from OT bedtime. Sleep must be scheduled from 0400 to 1200 DT or 2000 to 0400 OT. Daylight exposure after 1200 DT (0400 OT) will facilitate the advance of sleep onset during the first 3 days at the destination. Seeking daylight exposure after 1200 DT throughout the day (e.g., traveling to and from work, during breaks, exercise, lunch, and so forth) will promote the adaptation process (see table 6).

■ Pre-adaptation prior to travel is desirable and possible in this case. Since sleep onset must be rescheduled to 2000 OT, it is likely that adaptation can take place prior to travel without implementing complicated countermeasures. Using artificial bright light (portable light visors) or daylight exposure from 0400 to 0700 OT prior to travel will significantly speed the process of adaptation. Daylight-exposure/avoidance schedules will be required upon arrival.

■ Soldiers should be instructed to—

- Change their watches to destination time upon boarding the transport aircraft.
- Sleep only during the expected destination sleep period (0400 to 1200 DT).
- Observe the daylight-exposure schedule upon arrival.
- Take short naps (1 to 2 hours) prior to flight missions to boost alertness during the first week of adaptation to the new time zone.

■ If necessary, the flight surgeon may be consulted to prescribe a sleep aid for soldiers who have difficulty falling asleep during the advance of the sleep/wake cycle. Mandatory grounding times will be considered before administering any medication to aviators.

Table 6: Light Exposure After Eastward Travel, Nighttime Duty*

TIME ZONES CROSSED	DEPLOYMENT DAY	DAYLIGHT EXPOSURE OT	DAYLIGHT EXPOSURE DT	DAYLIGHT AVOIDANCE OT	DAYLIGHT AVOIDANCE DT
4	DAY 1-2	0800-SSDT	1200-SS	2000-0300	0000-0700
	DUTY 2000-0400 DT				
	DAY 3		1200-SS		
8	DAY 1-2	0400-SS	1200-SS	2000-0300	0400-BT
	DUTY 2000-0400 DT				
	DAY 3		1200-SS		

*IN THE FIRST COLUMN, IDENTIFY THE NUMBER OF TIME ZONES TO BE CROSSED. THE DAYLIGHT EXPOSURE AND AVOIDANCE SCHEDULES ARE THEN PROVIDED FOR BOTH OT AND DT ZONE. THIS TABLE ASSUMES THAT THE USER HAS BEEN ON OT FOR AT LEAST 2 WEEKS (I.E., STABLE ON OT).

Westward deployment—daytime duty hours. This scenario requires the resetting of sleep to begin at a later time of day, relative to the time zone at origin (delaying the body clock).

■ Delaying bedtime is generally easier than advancing the sleep cycle, as is required during eastward deployments. Sleepiness is likely to be experienced during evening hours (DT) until readjustment of the body clock is accomplished.

■ Unit members should maintain regular wake-up times in agreement with the duty schedule. Upon awakening, they should seek daylight exposure and avoid staying indoors the majority of daylight hours, particularly during the first 5 days of adaptation.

■ Pre-adaptation will require soldiers to wake up later (relative to OT) as many hours as time zones crossed.

Example. A mission requires daytime flights between 0700 and 1600 DT (1500 to 2400 OT) after rapid deployment westward across eight time zones. The challenge for the crew-rest planner is to provide countermeasures to prevent jet lag and prepare personnel for mission flights soon after arrival.

■ According to the mission work schedule (0700 to 1600 DT), sleep should occur between 0600 and 1400 OT or 2200 and 0600 DT. Therefore, adaptation to the new work schedule will require a bedtime delay of approximately 8 hours.

■ The delay of sleep onset from approximately 2200 OT to 0600 OT (2200 DT) can be facilitated by a daylight-management plan. The planner can consult table 7 for an 8-hour westward trip, and determine the destination clock times. The table indicates the times of day in which exposure to daylight will speed (1200 to 1900 DT) or retard (1900 to 2300 DT) readaptation during the first 3 days at the new time zone. It is important to seek daylight exposure between 2000 and 0300 OT or 1200 and 1900 DT during the first 2 days upon arrival. This does not mean that light should be strictly avoided from wake-up time to 1200 DT, but it does mean that daylight exposure between 1200 and 1900 DT will speed up adaptation to the new time zone. In this case, due to the westward shift, the avoidance period is likely to be after sunset, and there is little risk of significant unwanted daylight exposure.

■ After Day 2, daylight exposure should begin soon after awakening and continue throughout daylight hours as permitted by the work schedule. Wake-up time should be scheduled to precede the work period by at least 1 to 2 hours to allow for outdoor early morning activities if possible (e.g., favorable climate).

■ Pre-adaptation prior to travel is desirable, but may be difficult in this case. Since sleep onset must be rescheduled to 0600 OT, it is unlikely that readaptation can take place prior to travel without implementing restrictive countermeasures.

■ Using artificial bright light in the schedule indicated in table 7 (westward-daytime) (2000 to 0300 OT) prior to travel will significantly speed the process of adaptation. Daylight avoidance will be required from 0300 to 0700 OT. However, this pre-travel adaptation scenario requires sleep restriction and controlled light exposure for 2 to 3 days prior to travel, which may require specially equipped facilities and equipment.

■ Soldiers should be instructed to—

- Change their watches to DT upon boarding the transport aircraft.
- Sleep only during the expected destination sleep period (2200 to 0600 DT).
- Observe the daylight-exposure schedule upon arrival.
- Take short naps (1 to 2 hours) prior to flight missions to boost alertness during the first week of adaptation to the new time zone.

■ Although usually not necessary in westward deployments, the flight surgeon may be consulted to prescribe a sleep aid for soldiers who have difficulty falling asleep during the delay of the sleep/wake cycle. Mandatory grounding times will be considered before administering any medication to aviators.

■ Of all deployment conditions, this case should not usually require pharmacological countermeasures. When soldiers complain of difficulty falling asleep, the causes are less likely to involve circadian rhythm desynchronosis.

Table 7: Light Exposure After Westward Travel, Daytime Duty*

TIME ZONES CROSSED	DEPLOYMENT DAY	DAYLIGHT EXPOSURE OT	DAYLIGHT EXPOSURE DT	DAYLIGHT AVOIDANCE OT	DAYLIGHT AVOIDANCE DT
4	DAY 1-3	2000-0300	1600-2300	0300-0700	2300-0300
	DAY 4	1100-SSDT	0700-SS		
6	DAY 1-3	2000-0300	1400-2100	0300-0700	2100-0100
	DAY 4		0700-SS		
8	DAY 1-3	2000-0300	1200-1900	0300-0700	1900-2300
	DAY 4		0700-SS		
10	DAY 1-3	2000-0300	1000-1700	0300-0700	1700-2100
	DAY 4		0700-SS		

*In the first column, identify the number of time zones to be crossed. The daylight exposure and avoidance schedules are then provided for both OT zone and DT zone. This table assumes that the user has been on OT for at least 2 weeks (i.e., stable on OT).

Westward deployment—nighttime duty hours. Westward deployment combined with nighttime duty hours requires the resetting of sleep to begin at an *earlier* time of day, relative to the pre-deployment time zone. Therefore, difficulty in falling asleep during travel and upon arrival may be experienced. In deployments requiring crossing more than four time zones, sleep may take place at times too early for the body clock to readjust quickly. Soldiers may experience jet lag symptoms throughout the first 4 to 5 days.

Example 1. A mission requires westward travel crossing four time zones, and nighttime duty hours (2000 to 0400 DT) upon arrival. The unit plans to sleep after the mission from 0400 to 1200 DT (0800 to 1600 OT).

■ Adapting to the destination sleep period requires a delay of sleep of approximately 10 hours (from 2200 OT to 0800 OT). An alternate strategy would be to sleep from 1100 to 1900 DT (1500 to 2300 OT). However, this option may be more difficult to implement because it requires an advance of sleep onset of approximately 7 hours (from 2200 to 1500 OT).

■ Because the biological clock responds more readily to delays of its internal timing, it is better to use a daylight-management plan that involves delaying sleep onset. Therefore, the sensitive times of the day for a delay of sleep onset will include 1600 to 2300 DT (2000 to 0300 OT). This does not mean that soldiers should not be exposed to daylight after awakening at 1200 DT. However, exposure to daylight between 1600 and 2300 DT will speed the adaptation of the body clock to the destination work and light-dark cycle, particularly during the first 3 to 4 days of the transition. Thereafter, daylight management becomes less critical because exposure to daylight after awakening signals the beginning of the body's morning.

■ Pre-adaptation prior to travel is desirable, but may be difficult to implement in this case. Since sleep onset must be rescheduled to 0800 OT, it is unlikely that readaptation can take place prior to travel without implementing restrictive countermeasures.

■ Using artificial bright light in the schedule indicated in table 8 (westward-nighttime) (2000 to 0300 OT) prior to travel will significantly speed the process of adaptation. Daylight avoidance will be required from 0300 to 0700 OT. However, this pre-travel adaptation scenario requires sleep deprivation and controlled light exposure for 2 to 3 days prior to travel, which may require specially equipped facilities.

■ Soldiers should be instructed to—
- Change their watches to destination time upon boarding the transport aircraft.
- Sleep only during the expected destination sleep period (0400 to 1200 DT).
- Observe the daylight-exposure schedule upon arrival.
- Take short naps (1 to 2 hours) prior to flight missions to boost alertness during the first week of adaptation to the new time zone.

■ Although usually not needed in westward deployments, the flight surgeon may be consulted to prescribe a sleep aid for soldiers who have difficulty falling asleep during the delay of the sleep/wake cycle. Mandatory grounding times will be considered before administering any medication to aviators. Typically, this case should not require pharmacological countermeasures. When soldiers complain of difficulty falling asleep, the causes are less likely to involve circadian rhythm desynchronosis.

Example 2. A mission calls for an 8-hour westward time zone crossing combined with night operations upon arrival (2000 to 0400 DT). Therefore, the unit plans to sleep from 0400 to 1200 DT (see table 8).

■ The adaptation to the destination sleep period requires a sleep delay of approximately 14 hours (from 2200 OT to 1200 OT) or an advance of 10 hours. Because the biological clock responds more readily to delays of its internal timing, it is better to use a daylight-management plan that promotes delay of sleep onset. The sensitive times of the day for a delay of sleep onset will include 1200 to 1900 DT (2000 to 0300 OT). This is convenient because wake-up time is scheduled at approximately 1200 DT (provided that soldiers retire at approximately 0400 DT).

■ In this case, there are only 1 to 2 hours in the daylight-avoidance zone because the advance times for the body clock fall between 1900 and 2300 DT (0300 and 0700 OT), mostly after sunset.

■ Exposure to daylight between 1200 and 1900 DT will speed the adaptation of the body clock to the destination work and light-dark cycle, particularly during the first 3 days of the transition.

■ Pre-adaptation prior to travel is desirable but may be difficult. Since sleep onset must be rescheduled to 1200 OT, it is unlikely that pre-adaptation can take place without implementing elaborate countermeasures.

■ Using artificial bright light in the schedule indicated above (2000 to 0300 OT) prior to travel will significantly speed the process of readaptation. Daylight avoidance will be required from 0300 to 0700 OT. However, this pre-travel adaptation scenario requires sleep deprivation and controlled light exposure for 2 to 3 days prior to travel, which may require specially equipped facilities.

■ Soldiers should be instructed to—

- Change their watches to DT upon boarding the transport aircraft.
- Sleep only during the expected destination sleep period (1200 to 2000 DT).
- Observe the daylight-exposure schedule upon arrival.
- Take short naps (1 to 2 hours) prior to flight missions to boost alertness during the first week of adaptation to the new time zone.

■ In contrast to other westward deployments, it is likely that many soldiers will experience insomnia because bedtime occurs during the daily rise of core body temperature. The flight surgeon may be consulted to prescribe a sleep aid for soldiers who have difficulty falling asleep during the delay of the sleep/wake cycle. Mandatory grounding times will be considered before administering aviators any medication.

Table 8: Light Exposure After Westward Travel, Nighttime Duty Hours*

TIME ZONES CROSSED	DEPLOYMENT DAY	DAYLIGHT EXPOSURE OT	DAYLIGHT EXPOSURE DT	DAYLIGHT AVOIDANCE OT	DAYLIGHT AVOIDANCE DT
4	DAY 1-2	2000-0300	1600-2300	0300-0700	2300-0300
	DUTY 2000-0400 DT		1200-SS		
	DAY 3		1200-SS		
8	DAY 1-2	2000-0300	1200-1900	0300-0700	1900-2300
	DUTY 2000-0400 DT				
	DAY 3		1200-SS		

*In the first column, identify the number of time zones to be crossed. The daylight exposure and avoidance schedules are then provided for both OT zone and DT zone. This table assumes that the user has been on OT for at least 2 weeks (i.e., stable on OT).

INDEX

A

B

C

D

E

F

G

H

J

L

M

N

P

R

S

T

W

Z